Quark®

Research and Development in Slovenia

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Sixth Framework Programme
2002–2006

TransSLO

Increasing the participation of Slovenia in European transport research projects

As of January 2007 the 7th European Framework Programme for Research will be begin. The first call for proposals for new EU research projects will be opened on 22 December 2006. Many opportunities will be presented to receive EU funding for research projects that will deliver results important to Europe. For companies, research institutes, small to medium enterprises and universities from the new Member States, like Slovenia, it is important to collaborate with previous partners to use the experience of older Member States. Slovenian EU Commissioner Janez Potočnik, who was involved in the development of the 7th Framework Programme, considers that "For the EU to fully embrace the knowledge era, the knowledge for growth pact should aim at reinforcing the knowledge triangle (education, research and innovation) and make it productive via its integration with policies that bring about favourable and supportive framework conditions. It should involve the social partners at the EU level and could easily be translated into national agreements between all concerned stakeholders".

To encourage this collaboration a new European project recently began, supported by a grant from the EU. TransSLO will run to April 2008 and is designed to increase the participation of Slovenia in the field of transport research and the integration of Slovenia in the ERA (European Research Area). The overall aim of TransSLO is to prepare, strengthen and network the transport research community in order to expand participation in European projects through the cooperation and networking capability of the surface transport research community and form methods of cooperation and strong relationships for future collaboration. The overall aim of the project is to use the scientific and research potential of the networked research community to connect the academic environment and industrial practice. One of the important aspects of any enhancement of economic progress in Slovenia is the transformation of the transport industry.

The project will focus on four main actions:

- Organising a competition of PhD studies in the field of transport, the best of which will be presented during the Slovenian ISEP 2008 Conference
- Setting up a database of companies, research institutes, organisations and universities involved in transport research facilitated through the Slovenian Transport Research Workshop 2007
- Mapping areas of strengths (and weaknesses and needs) of Slovenian transport research
- Presenting of the final results of the TransSLO project during the EU Transport Research Arena (TRA) Conference in Ljubljana in April 2008

Republic of Slovenia
Ministry of Transport

The result will be a network of academic and industrial players in Slovenian transport research and an overview of their strengths and fields of expertise. Workshops will be organised to inform and train Slovenian researchers and make them familiar with the procedures necessary for successful participation in the 7th European Framework Programme for Research.

The TransSLO project is coordinated by the Director of SLOVENIA CONTROL, Slovenian Air Navigation Services, Mr Srečko Janša. Project partners include: NewRail, the Centre for Railway Research at Newcastle University (UK); the Ministry of Transport of the Republic of Slovenia; and the Electrotechnical Association of Slovenia (EZS).

KONTROLA ZRAČNEGA PROMETA SLOVENIJE
SLOVENIA CONTROL, Slovenian Air Navigation Services, Limited

newrail

For more information, please contact.....

For more information about the EU 7th Framework Programme for Research, see
http://www.cordis.europa.eu
http://www.ec.europa.eu/research/aeronautics/index_en.html
http://www.ec.europa.eu/research/transport/index_en.html

Cover photo:

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Conservation and Management of Wetlands in Slovenia.

Dr Marjan Bele is presenting a new Field-Emission Scanning Electron Microscope (Karl Zeiss Supra 35 VP) to Dr Janez Potočnik, the European Commissioner for Science and Research.

Prof Dr Tamara Lah, Director of National Institute of Biology.
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The New Marine Biology Station

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Balder is a typical "spin-off" company. ..

Greater cooperation means a more flexible response to promising opportunities

We have designed Quark to meet two core needs. First, it must offer an ample choice of articles of interest to the discerning reader. Second, a careful reading of the articles selected in this edition must provide the reader with a clearer picture of work and events in Slovenia's research and development field. Quark must also quickly offer readers unfamiliar with Slovenia from the R&D point of view an impression of the level of research and development activity in our country. We use the term "impression" because Quark is after all a review, which means that rather than necessarily presenting the very best of Slovenian R&D, each edition focuses on new themes and the very latest development work and research results.

I would like to mention the theme that, as editor of this issue of Quark, has struck me more than any other past theme. That is, the thorough and diverse nature of collaboration today. For some years, the opinion has largely been held in Slovenia that there is significant commitment and engagement, and sufficient desire, to collaborate in research and development. Quark for its part has always focused on the importance of collaboration and cooperation. Yet that desire has been contrary to the finding that Slovenia has not reached the level we think it should, compared to the most developed regions of Europe, even when we look at per-capita figures. Too many opportunities are being left unexploited. Efforts in this direction are, however, strengthening, as we describe in this edition of Quark.

The European Commission's development projects represent a major incentive for cooperation. Not only do these projects create new collaboration and partnerships, but they also have a very interesting secondary impact. To take part, you have to be properly qualified in terms of specialist knowledge and organisation, which is generating cooperation and collaboration at every level in Slovenia as a whole. Indeed, at least in the next few years, Slovenia may well be one of the countries that benefit more from this secondary impact of joint EU development work than from joining the actual project.

Boris Čerin, Editor

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On 15 March 2006 the Jožef Stefan Institute and Joanneum Research signed a cooperation agreement on exchanging information and experience in research and practice in a number of areas.

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The New Marine Biology Station

Minister of Higher Education, Science and Technology, Dr Jure Zupan.

Prof Dr Tamara Lah, Director.

Prof Dr Tamara Lah, Director:

The number seven is, for whatever reason, considered a lucky number, and as it happens it is the number of years since we started to build the new Marine Biology Station. It was also in the seventies of the last century that this research group was started by Prof Dr Jože Štirn. And although he could not be present here today, we would like to thank him for his enthusiasm and the vision that guided him, not only in academic terms, but also to literally pave the way for the development of marine biology in Slovenia. I will also use this opportunity to thank again the famous Slovene biologist, Prof Miroslav Zei, the recipient of the highest Slovenian state award and also the first director of the Institute of Biology, which was established at the University of Ljubljana in 1960 After Prof Štirn, the lead of the Marine

Biology Station was taken by Prof Dr Alenka Malej, the acting director until now. The successful development of the Station is associated with many Slovene biologists who added small pieces of knowledge to the mosaic of present activities, hopefully to be further expanded in the future. This marvellous building, standing on this part of the Slovenian coast, is one of the prerequisites and to some extent a guarantee for the development of high-quality science,

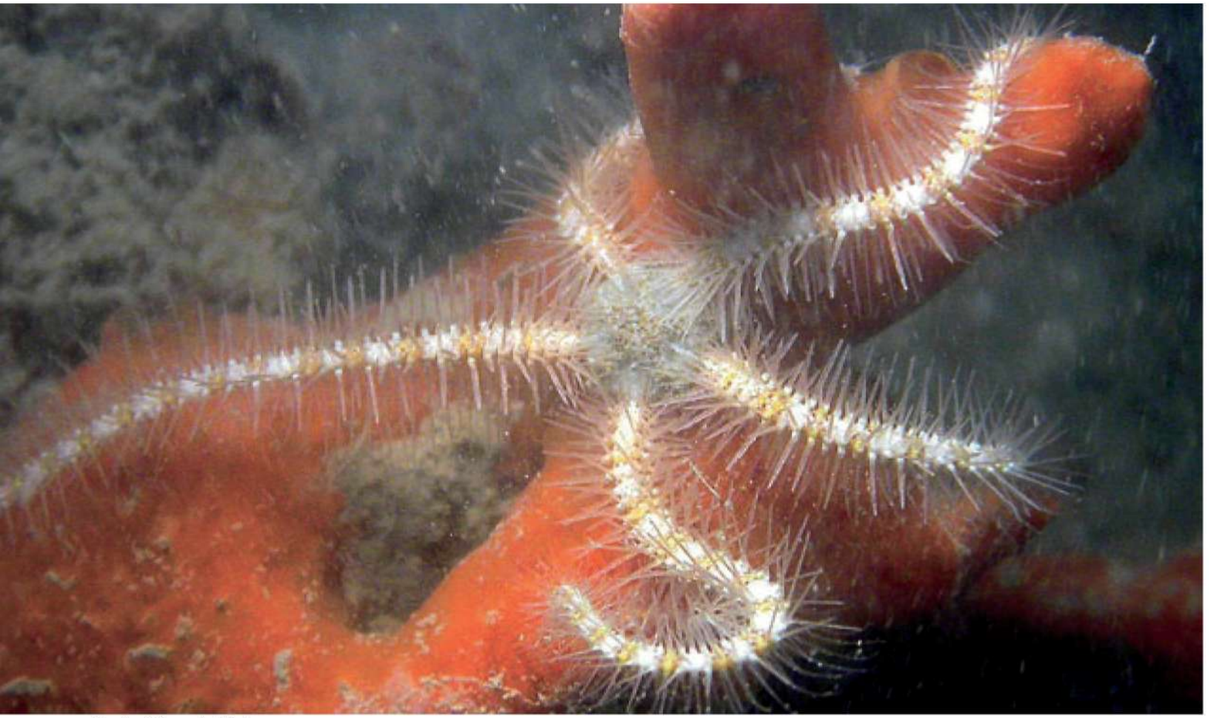


Photo: Tihomir Makovec

Prof Dr Tamara Lah, Director.

which nowadays very much depends on state-of-the-art technological infrastructure.

The development of the scientific quality of the marine biology research group is also connected with many foreign research teams and fans of the sea – as the sea knows no borders! Let me mention only the collaboration with neighbouring Croatia, being very close at previous times and hopefully more intense again in the future, and with Italy, another close neighbour, particularly with scientists from the University of Trieste, which will be among the partners in the planned Joint Degree Study of Marine Biology. Furthermore, connections are particularly strong with all countries surrounding the Mediterranean Sea which are dedicated to the so-called Mediterranean Action Plan, formally headed in Slovenia by the Ministry of the Environment. There are also connections spread across the oceans – from the USA to Australia – and here I should particularly stress the membership in the IOI, the International Ocean Institute, of the Marine Biology Station; IOI is a virtual institute, an association of many oceanographic institutions, supported in Slovenia by the International Center for the Promotion of Enterprise.

Knowledge at the MBP ranges from biology and chemistry to physics and computer sciences, to be strengthened in the future by molecular biology. As for the future, we also hope that more young researchers will find their working environment here; we hope for a more intense flow of information from our new library to many different target publics all along our coast and that in our lecture rooms the seeds of knowledge will be spread to young generations of students from here and abroad. This young generation will

Photo: Tihomir Makovec

Photo: Tihomir Makovec

also benefit from the new dormitories, lodging and diving facilities in this building.

The common denominator of our research is not only the sea and investigating the basic biological processes of the marine and other organisms. In recent years, more and more attention has been paid to the preservation of this origin of life and related ecosystems in the best possible natural and sustainable form. Here, science merges with the everyday needs and wisdom of other fields in one single intention: to leave this world to the next generations in at least the same, if not better, condition as we got it from our parents. This is our message to eternity – from us who care, from us who are here today to inaugurate this new temple of knowledge.

To end, I would like to thank everyone who supported us during these seven years: the highest ranking representatives of the Ministry of Higher Education, Science and Technology, Minister Dr Jure Zupan and all previous Ministers, starting with Dr Rado Bohinc, Prof Dr Andrej Umek, Prof Dr Lojze Marinček, Prof Dr Lucija Čok and Prof Dr Slavko Gaber. I also wish to thank many other coworkers at thise Ministry. Also, I thank the Ministry of Environment, which made many of our activities possible, for their continued support. Here, I cannot help but mention the architect, Mr Stane Mikuž, with whom almost as "conspirators" we hatched the idea of rebuilding the MBP, which we hoped would also include a big aquarium – we still have not completely given up hope for that to be realised in the future. I should also mention the great support and collaboration with the construction company SCT. Finally, thanks to the many business partners, too many to be mentioned in this short speech, co-workers and friends who supported us – thank you for being here and thank you for the good wishes and help when we needed it the most.

HEVREKA!

Hevreka! 2006

Paving the Way to a Technological Tomorrow

The second annual event on the Development Strength of Slovenia took place in Ljubljana in late October

By Andrej Gregorc

Slovenian technology companies have always been aware that presenting their achievements, bringing new trends closer to users and discussing the future with their partners are crucial parts in the successful process of turning inventive ideas into business projects. Over decades, many regular events, conferences, gatherings, fairs and meetings have been organized. Worthy of mention among them is the Ljubljana Electronics Fair, which was held for 50 years in a row. The latest fast-paced development tendencies towards hi-tech convergence and multidisciplinary approaches also reflected the need for a broader, joint Slovenian annual technological event. In 2005, the Electronics Fair and the annual ICT events Infos and Teleinfos were combined to form Hevreka! – an upgraded and enhanced event featuring Slovenian technological development.

Vesna Kastelic presenting the most popular Slovenian web search engine, Najdi.si.

Andrijana Starina Kosem, MSc, State Secretary, Ministry of the Economy, presenting the awards to innovators after giving a speech at the opening ceremony of Hevreka! 2006.

Hevreka!'s new scheme received wide support among companies, universities, research institutes, government agencies, ministries and institutions, technology networks, platforms, parks and clusters, professional unions and associations, and other organizations. All of these groups participated in the organization of Hevreka! 2006. Hevreka! has positioned itself as the leading Slovenian event in the area of innovation and technological development, presenting the results and achievements of R&D projects, the latest development trends, programmes and policies to support innovation, creativity, entrepreneurship and technological excellence. Hevreka! also focuses on further improving the transfer of knowledge and the exchange of ideas, know-how and experience, with special emphasis on cooperation between faculties and research institutes, on the one hand, and companies on the other.

Several independent forums and events were also co-organized with Hevreka! 2006. The Slovenian Innovation Forum received by far the largest representation and attention, as it featured 285 innovations submitted for evaluation. The top 50 of them were presented at the event, which also included a "match-making centre" which enabled inventors to connect with investors, advisers and company representatives, and perhaps even close a deal on the spot. The Slovenian Research Forum brought about new approaches in cooperation between the public and private sectors, the Slovenian ICT Forum featured the latest achievements and potential of the 46 members of the Slovenian Technology Network ICT, while the Slovenian Knowledge Society Forum connected all participants in the process of knowledge acquisition. The Vitel 2006 International Symposium focused on the problems of content generation and provision, as well as problems of content access via existing and future electronic communication networks. Also co-organized with Hevreka! 2006 were the Technology Platform E-mobility Conference and several student events.

Dr Andrej Kitanovski, director of the Enterprise and Competition Directorate, Ministry of the Economy, Andrej Vizjak, MSc, Minister of the Economy, and Prof Dr Janez Bešter, Faculty of Electrical Engineering, explore the ideas submitted to the Slovenian Innovation Forum.

Dr Jure Zupan, Minister of Higher Education, Science and Technology, gets acquainted with the GENESIS platform of DSPLAB, Faculty of Electrical Engineering and Computer Science, University of Maribor, after giving his opening remarks on the second day.

The audience fills one of the halls in Cankarjev Dom, Ljubljana, the venue of Hevreka! 2006.

Andrej Vizjak, MSc, Minister of the Economy, delivering his address during the closing remarks at Hevreka! 2006.

Besides forums and parallel events, the 3-day programme included many presentations, speeches, panel discussions, demonstrations, exhibitions and other events, all aimed at culminating in new hi-tech products, services, top-skilled experts and new enterprises. The good response from all the participants, the professional public and random visitors confirms the need for such a strategic event. There are still many challenges ahead for future Hevreka! events – strengthening its position within the Central European region, attracting enlarged international participation and launching original solutions. The chance for implementation is already coming next October.

Left:
Visitors absorbed in testing the equipment.

Andrej Polenec, general manager of Iskratel, giving an interview to the local media.

A representative of the legendary Slovenian company Elan elaborates new trends and solutions, including the award winning WaveFlex technology, in the field of up-to-date ski equipment.

Dr Jure Zupan, Minister of Higher Education, Science and Technology, during his opening remarks on the second day.

Prof Dr Matjaž Jurič, Faculty of Electrical Engineering and Computer Science, University of Maribor, and chairman of national committee of the Slovenian Innovation Forum, listens attentively before joining the discussion.

The audience also included Andrej Vizjak, MSc, Minister of the Economy, and many Slovenian managers.

Dr Franci Demšar, director of the Slovenian Research Agency, during his opening remarks on the third day of Hevreka!.

Dr Alex Smeets, St John's Innovation Centre, giving a lecture on the innovative cluster in Cambridge.

Andrej Pengov, host, Japec Jakopin of Seaway, the world's leading boat development company, and Dr Andrej Kitanovski, director of the Enterprise and Competition Directorate, Ministry of the Economy, in a panel discussion.

Žiga Osolin, high-school student at Gimnazija Bežigrad, receives the gold award for a student research thesis from the ceremony host Andrej Pengov, Prof Dr Tomaž Slivnik, Dean of the Faculty of Electrical Engineering, and Dr Franci Demšar, director of the Slovenian Research Agency.

Filip Remškar, president and CEO of Smart Com, presenting on behalf of the Technology Network ICT the project IRIS Home, which takes advantage of ICT technologies and solutions in intelligent homes for the elderly or those in need of medical or other special care.

Hevreka! 2006 Facts

over 550 innovators
900 business representatives
650 researchers and developers
131 exhibitors

Hevreka! 2007
Development Strength of Slovenia
Ljubljana, Slovenia
October 16 – 18, 2007

www.hevreka.si

Organizer: INFOS
Co-organizers: Ministry of the Economy, Ministry of Higher Education, Science and Technology, Technology Network ICT

Many high-tech demonstrations taking place during Hevreka! 2006.

Primož Sark, PR representative of the Slovenian Research Agency, in a conversation with a student from IAM – Multimedia Institute and Academy Higher School.

Jerneja Žganec Gros of Alpineon presenting the R&D project Voicetran, a voice communicator for consecutive two-way language translation, comprising speech recognition, machine translation and voice synthesis.

Unwinding at the social event after a full day of lectures, seminars, panel discussions and meetings.

Hevreka! 2006 programme council in session drafting the final programme for the event.

Matjaž Janša, MSc, director of the Electronic Communications Directorate, Ministry of the Economy, chairing the session of the Forum for Digital Radiodiffusion in Slovenia, which also took place during Hevreka! 2006.

Panel discussion at the Slovenian ICT Forum.

By Dragica Bošnjak
DELO

The Priority of Systematically Organised Cooperation in Research

Professional director of the Clinical Centre, Prof Dr Saša Markovič, MD.

Prof Dr Jadran Lenarčič, director of the Jožef Stefan Institute in Ljubljana.

Many common interests with the Clinical Centre in biomedicine

"Linking up with the Ljubljana Clinical Centre is part of the Jožef Stefan Institute's work. In this way we want to bring our institute as close as possible to the local environment and at the same time jointly break through to the top European level. The association between IJS and the CC is based on our firm belief that Slovenia has great opportunities in research and development in the fields of health and biomedicine. To this end we are seeking to bring together physicians, natural scientists and various fields of technology in the common research, development and education sphere," pointed out IJS director Prof Dr Jadran Lenarčič.

He added that the meeting was on a level of quality they had never had before between the two institutions. He took the view that "these two institutions, which are so very important for Slovenia, must bear the burden of developmental challenges and responsibility for scientific and technological advances in the field of medicine. I am entirely convinced that such shifts and technological breakthroughs are feasible. I myself see them in the synergies that are generated by links between the two institutions and, of course, later also in cooperation with successful Slovenian companies."

"In order to step up the links between the two institutions, we intend to establish a joint scientific and research council to head and coordinate various research and development projects; one such opportunity, for example, is bidding for structural funds financing. We seek cooperation in joint national and international projects, especially within the European Community's 7th Framework Programme. We see a major opportunity here, since our advantage is an interdisciplinary approach and an interweaving of science with clinical practice. We wish to create the conditions for exchanging young researchers, and we wish to collaborate in acquiring common equipment and especially in the development of new specific equipment and in the development of new methods or apparatus for use in diagnostics and treatment." Prof Lenarčič added that in view of the good experience with such talks, they would continue with issue-oriented and interdisciplinary meetings. Prof Lenarčič also sees good prospects for cooperation in setting up new, specialised institutes outside Ljubljana, perhaps in less developed municipalities.

We already have some experience in cooperation between physicians from the Clinical Centre and IJS researchers, but both groups know how difficult it was to coordinate, especially in terms of timetables, our desires with the needs and available capacities. There are most certainly enormous possibilities for joint research and development in the area of health and biomedicine, so of course we need to link up physicians and natural scientists and various technical fields in a common research, development and educational sphere. In this way the professional director of the Clinical Centre, Prof Dr Saša Markovič, MD and Prof Dr Jadran Lenarčič, director of the Jožef Stefan Institute in Ljubljana, confirmed the same thing in different words, not simply a common desire, but in line with the presentation of programmes and research fields, more specific plans for closer cooperation between the two institutions.

Over 600 researchers registered at the CC

Asst Prof Dr Ksenija Geršak, MD, on the scientific and research activities of the Ljubljana Clinical Centre:

A presentation of the whole range of activities in which physicians and associated experts from various specialised fields within the Ljubljana Clinical Centre (CC) conduct scientific and research work, given to a meeting of researchers at IJS, the heads of the university and others, undoubtedly confirmed the many common interests and the need for closer cooperation. For some time the CC has been preparing an overview of research work to date, and it is also striving to provide a better systemic framework for this field. The aim is for such activities to be as far as possible in line with the interests of the CC and not just of the individual researcher, who for this reason deals unnecessarily with a mass of additional problems. They have therefore already set up a special R&D unit and have started dealing systematically with these very issues. A part of this and – by way of introduction – particularly of the question of how scientific and research work at the CC is defined and regulated in formal legal terms, organisationally, financially and in all other respects, forms the subject of our conversation with Asst Prof Dr Ksenija Geršak, MD, assistant professional director of the CC for scientific and research activities.

Asst Prof Dr Ksenija Geršak, MD, assistant professional director of the CC for scientific and research activities.

The research work at the Clinical Centre is defined by its statutes. It extends to the performing of research within the framework of the healthcare plan and the national research programme. Research is carried out for domestic and foreign clients. Closely linked to this is the training of young researchers, providing mentors in research assignments, providing expert review work of proposals and results of research projects for various clients, and also organising scientific, research and expert meetings.

The scientific and research work of the CC is headed by the Research Council, which formulates guidelines for scientific and research activities, monitors the results, evaluates fulfilment of the research programme, formulates initiatives and priorities for research and development projects and similar.

The financial resources for scientific and research work are provided through the Institute for Health Insurance of Slovenia (ZZZS) as part of its tertiary activities, and the CC also applies for budget funds in public tenders issued by the Slovenian Research Agency, while we also strive to obtain EU funds by applying to the relevant international tenders.

In addition to the above, the relevant regulations also define scientific and research work for other external clients and cofinancers.

What is termed tertiary activity is a constituent part of the Sectoral Agreement for Hospitals with the ZZZS. This binds us contractually to ensure the provision of the highest expert level of healthcare, research, development and implementation of new knowledge in the fields of national pathology and the transfer of knowledge and skills to health workers and healthcare associates of all levels, and to formulate guidelines for the entire country or a significant part of the country. This tertiary programme of development and research covers: the development of methods and procedures from existing knowledge, for instance the transfer of new methods of treatment or diagnostics from abroad, basic research to solve national pathology problems, the development and training of new research teams and so forth. All this involves active work with young researchers and mentorship for medical students doing master and doctoral degrees, as well as the participation of young doctors and other health personnel in clinical studies and so forth.

In view of the fact that the Clinical Centre, as its title suggests, is for the most part a hospital institution, from which we expect top hospital services, can you tell us what proportion of their time can staff devote to the scientific and research activities that you mentioned – or rather what proportions would be ideal?

In a university hospital this proportion should represent up to 20 percent of the work. If we look at the proportion of work in terms of the financial resources of the CC together with tertiary research and development work, it is around 11 percent.

At one time, when we were still in the common Yugoslav state, the Clinical Centre was a recognised and sought-after health institution. It had several excellent clinical fields that enjoyed fame and where health services were sought even by patients from abroad. Moreover the CC once also had the word "university" in its name. For some time it has no longer had this designation, but it will supposedly reacquire it. Under what criteria and in comparison with which European clinical institutions can it reacquire that title?

The CC has again requested the return of its university title. Since we meet the criteria, the university agrees with this, but we still need an amendment to the founding act, which as we speak is still in the process of adoption in the government. Since this involves professional activities, I should point out that the CC still provides education for numerous physicians from the former Yugoslavia. Via the Ministry of Health we are cooperating officially with the Republic of Montenegro, and talks are currently in progress for the formalisation of such cooperation with Bosnia and Herzegovina. And we are still receiving patients for treatment from the former Yugoslav republics, although less than previously. The reason for this is the poor financial situation in those countries. EU accreditation is currently underway in the area of postgraduate education, and four clinical departments at the CC have already been officially accredited as European teaching centres. A comparison of hospital work and results is only just being organised in Europe, along with a standardised accreditation of hospitals. At the CC itself right now we are performing benchmarking with two university hospitals abroad. The entire process of accreditation and hospital benchmarking in the EU is only just getting started.

In order to achieve excellence in a clinic, it must necessarily be linked to relevant basic and clinical research work. Numerous clinical physicians are for this reason at the same time university professors. What formal legal, organisational, working and other conditions must be met for these popularly termed "amphibious" professors (and/or clinics) to be successful in both fields?

With the well-known headaches over equipment and deficient infrastructure, over-employment and so forth, how can they perform high-quality clinical and teaching work, while at the same time being supposedly established researchers? In this connection one should also add the well-known problem of extensive tender "paperology", which, as they say, further exhausts those applying for international research projects. At the meeting at IJS an initiative was mentioned whereby several research institutions or individuals would create a joint so-called service activity to assist in tender applications.

Many of the things you mention in this question are highly complex. A comprehensive answer would require a thorough analysis, so for now I should limit myself to just a few numbers. At the Clinical Centre approximately 80 physician-researchers are at the same time educational staff at the University of Ljubljana Faculty of Medicine, covering basic pre-clinical and clinical subjects, while more than 150 staff are involved in the teaching process.

Can you point out any especially interesting Slovenian and international projects or fields headed by physicians/researchers from the Clinical Centre – and have they been successfully concluded in the recent past, are they in progress or are you planning them?

The CC performs research work in the field of medical disciplines: microbiology and immunology, stomatology, neurobiology, human reproduction, cardiovascular medicine, and metabolic and hormonal disturbance.

Prof Dr Boris Turk, acting head of the biochemistry and molecular biology department.

Researchers are organised into 33 research groups allocated to the SPS Internal Clinic, SPS Surgical Clinic, SPS Paediatric Clinic, SPS Gynaecological Clinic, SPS Neurological Clinic, SPS Stomatological Clinic, the Infectious Diseases and Fever Clinic, the Nuclear Medicine Clinic, Eye Clinic, Dermatovenereological Clinic, Orthopaedic Clinic, the Radiology Institute, the Clinical Institute for Clinical Chemistry and Biochemistry, and the Clinical Institute for Occupational and Sports Medicine.

There are more than 600 registered researchers and more than 200 technical and professional staff. At this time they are involved in 51 projects within and outside the CC, both as project leaders and collaborators. The majority of projects (38) will be concluded in 2007, and just a few in 2008.

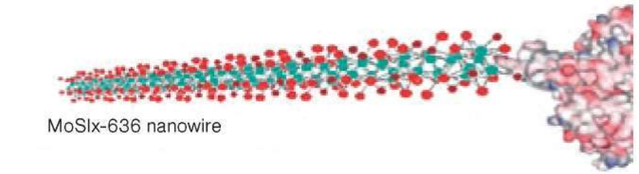
Parallel to this there are 15 programmes underway that will be concluded in 2008. We are also participating in five European projects, one of which we are leading. For all this we are drawing up a ten-year report. When this is completed, it will make available much more data, including a great deal on the subjects you asked about, and this will undoubtedly be of interest both to experts and the general public.

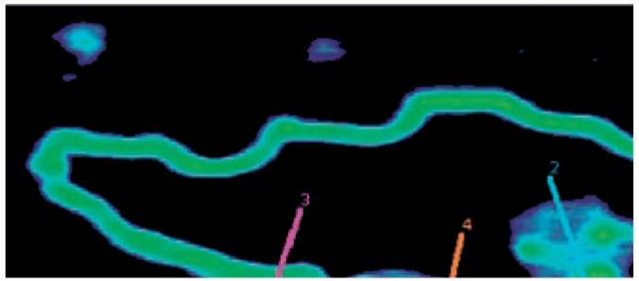
Prof Dr Boris Turk, acting head of the biochemistry and molecular biology department:

Modern medical research has outgrown its boundaries, so now we must speak of biomedical research. In short we no longer have just physicists, chemists or environmentalists, no longer just doctors with their clinical research, and in the same way we no longer have just biochemists with their basic research, but rather studies performed on complex systems. The complex system in this case is the human being and human health. One of the main findings here is that life expectancy is increasing, and with longer lives we are encountering diseases that are defined as diseases of the developed world. And the major share of financing is aimed precisely at their treatment and of course also at research intended for their treatment. We continue of course to have diseases of the developing world, for which less money is provided, although at least some of them, such as AIDS and malaria, which have come into contact with the developed world, have gained precedence on the international scale.

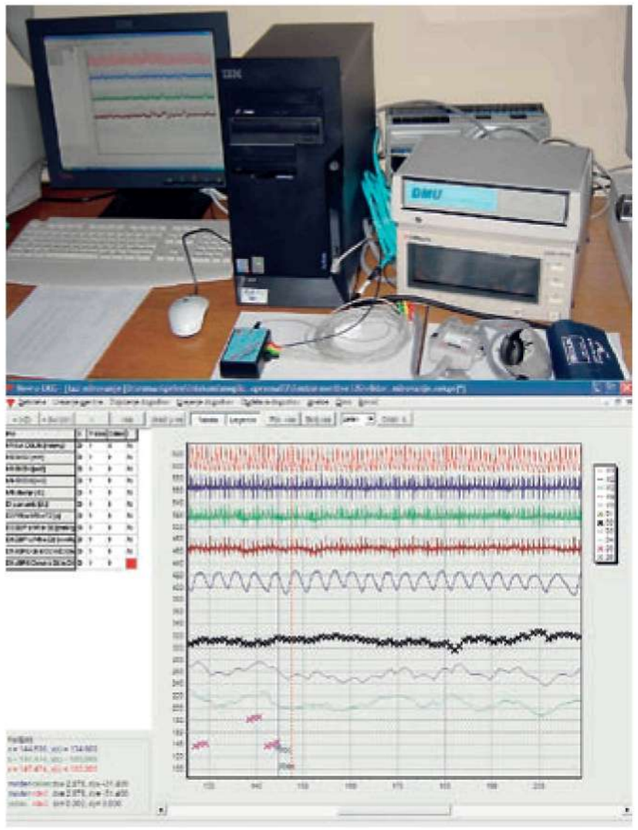
In the past, clinical studies were performed on the basis of a specific number of patients and statistical data. But such clinical studies tell us nothing about the causes of disease, although your doctor will of course offer a diagnosis based on observation, for instance that you have inflamed eyes and are coughing, and prescribe treatment.

Successful treatment requires knowledge of the molecular mechanisms of illness. If we dwell for a moment just on the question of why we cannot cure all types of cancer in the same way, we can already obtain one of the answers on the molecular level: because each form of cancer has its own molecular source. Here at the actual level of proteins and communications between them there can arise short circuits, faulty communications, the consequence of which is illness. And a complex approach is required in order to study these processes. The development of methodology involves the cooperation of physicists, chemists





Schematic diagram of the connection of a nanowire and a protein (above), and an AFM image of the future biosensor with a MoSIx-636 nanowire (purple line) attached via a gold connector (orange line) to a protein (Thyroglobulin) (blue line)



NeuroEKG measuring device for simultaneous measurement of electrocardiogram signals, respiration and blood pressure (above), and the measured signals (below).

and physicians; in short, there is a clear need for a range of different skills.

In modern biomedicine efforts are focused on the earliest possible detection of disease. There are increasing numbers of screening tests, where we can speak of a kind of individual medicine, in short, it is important to evaluate the factors of risk that a person has as an individual, in other words the factors why that person might become ill earlier. We also want to use the most patient-friendly methods of investigation.

With regard to cooperation between the Jožef Stefan Institute and the Clinical Centre, we can say that this was established based on individual initiative. With an interest in joint research work, experts from the two institutions had the chance to collaborate. I personally do not have much experience in this field, but recently, that is in the last two years, I have been working with Prof Blaž Rozman of the Rheumatology Centre. We intend to strengthen this cooperation further. We are also collaborating in the field of orthopaedics with Valdoltra Orthopaedic Hospital. The role of the IJS experts is to attempt to determine the molecular mechanism, what takes place in the actual cartilage to cause wear, and why damage is caused – this is in osteoarthritis – and what the mechanism of inflammation is that triggers the whole process in rheumatoid arthritis.

Cooperation has also been set up in the area of osteoporosis, where new drugs based on protease inhibitors will bring a minor revolution to the method of treatment.

There are still opportunities open in the field of stomatology, in which we already collaborated a few years ago. We continue to be interested in the field of neurology, with which we come into frequent contact. Ninety percent of our more ambitiously conceived research is in the field of biomedicine, where we deal with the molecular mechanisms of disease. This demands knowledge of both the clinical profession and knowledge of molecular biology and cell biology. Exchanging experience from a variety of research is essential. The physicist will know his part, we the biochemists will know ours, while the physicians will have clinical observations or findings based on experience and their specific knowledge. If I might mention biosensors, we need someone to assess, for example, whether it involves a protein molecule, which then linked to a nanoparticle is still functionally active. A biochemist will know this. In short, a thorough interweaving of different disciplines and branches is present.

Together with physicists, we are involved in a European project on safety on the nanotechnology level, the project Nano Safe II, which covers research on the harmfulness of nanoparticles, which are frequently found in cosmetics, and on the dangers posed by inhaling them, or rather in what doses these particles can be harmful. We are determining their toxicity on the cellular level. In animals we are studying how these nanoparticles are distributed around the body, and very importantly, whether the body then excretes them or whether they accumulate and affect health. The pharmaceutical industry is also involved in this area of research, although it is a few steps behind, but since it has increasingly strict criteria for determining all kinds of undesired effects on the body, it requires research on the effects of nanoparticles.

Nanoparticles are also involved in our work on cancerous cells. We use them as carriers of active substances that should arrive at the right location, and they can also function themselves as active substances. Some of the researchers in our department are also working on this kind of research.

Cancer research is being conducted very intensively throughout the world, and a range of important findings have been assembled, but a range of important issues remain unexplained. Thus research is being conducted into why cancerous cells do not die, and consequently multiply unchecked. The question of why the usual mechanism on the basis of which the lifecycle of the cell is regulated has malfunctioned is still with us. A cancerous cell does not die like an ordinary cell and does not yield its place to a successor cell, but continues living. Clearly it has found some bypass and has skipped over the normal protection mechanisms. We can ascribe some of the reason for the failure of earlier research to a lack of knowledge of molecular diagnosis, which has been available to us more recently. The difficulty lies in the fact that there are numerous forms of cancer, each with their own molecular diagnosis, which we must in no way generalise, since the discovery of an individual mechanism for one type of cancer does not mean that it will be applicable to others. Some mechanisms are generally known, but it appears that the difficulty does not lie simply on this level, and a more complex issue is involved. Nevertheless, the discoveries of mechanisms on the molecular level have significantly opened up the scope of our knowledge.

Prof Dr Dragan Mihailovič

As I have already mentioned, cooperation between the Ljubljana Clinical Centre and the Jožef Stefan Institute has already been pursued on the individual level. Now we wish to establish this cooperation between the Clinical Centre and the Jožef Stefan Institute on a more integrated systemic organisational footing, although the Clinical Centre with its 500 researchers and the IJS with 700 researchers are like two big ships that require considerable time to shift to one side or the other, so a fair amount of water will still have to be crossed before we can actually place our cooperation on a systemic level. One possibility is to set up a joint scientific council, which will put together those people who wish to collaborate professionally with the other side.

Physics and Medicine

Prof Dr Dragan Mihailovič:

We know that in this century progress in medicine will be revolutionary, and our physicists are therefore appropriately motivated to collaborate on joint research assignments with physicians from the Clinical Centre. Here it is worth mentioning especially that physics offers new methods that will be applicable in diagnostics and in understanding biological systems, while it also offers the advantage that the majority of the apparatus that physicists use for their own research can, with appropriate adaptation, also be used in medicine. We might mention just magnetic resonance and PET scanners.

Over the past decade we have encountered findings that biological systems are in fact quantum systems, and we are therefore attempting to understand the basic systems on a quantum level, in other words in the micro-world of individual atoms. Here there are important foundations that cannot be described by classical chemistry.

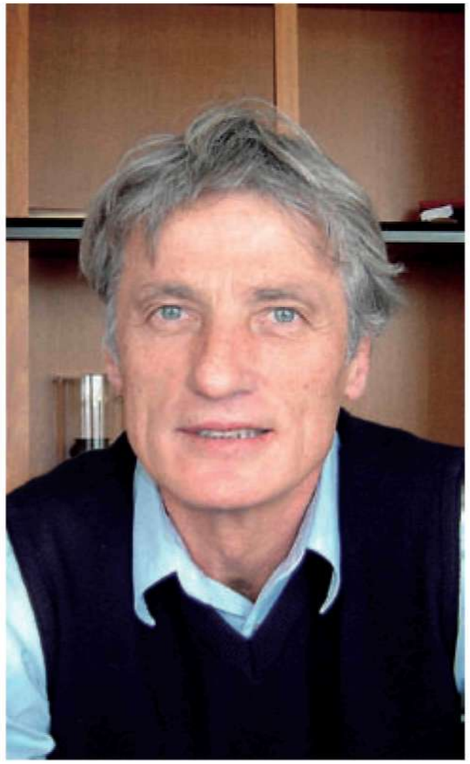
Furthermore we possess a range of new diagnostic methods that derive from physical measurements of experiments. For example, the use of optical spectroscopy can show how proteins age, as was recently researched in the case of human lenses. Here doubts arose concerning the valid explanations to date as to why the lens of the human eye ages. It appears that what was until recently accepted as the most probable explanation is not valid. Such things occur frequently in science, and in medicine there are a great many multidisciplinary possibilities.

The major activities of physicists at the Jožef Stefan Institute include work in the field of radiomedicine, the use and development of PET and magnetic (MRI) scanners and development of various entirely new methods in the laser surgery of teeth, eyes, skin and so forth. It makes sense to use the expertise that we offer in procuringnew, expensive apparatus at the cutting edge of technology, which is highly effective indiagnostics, such as PET-CT or MR scanners, which cost several millions of euros.

Mention should also be made of the importance of physics in molecular medicine, especially nanotechnology, which represents a distinctly interdisciplinary field and in which the cooperation of physicists and physicians is essential. This is a very promising field. Great expectations, already highly justified, are tied to the introduction of nanotechnology for medical purposes. There is also great interest among students in the field of nanotechnology, which indicates a wider identification of the importance of this field.

Asst Prof Dr Roman Trobec, representative of the electronics and information technology departments:

The electronics and information technology departments at IJS, which cover automation, biocybernetics, robotics, management systems, open systems and networks, communication systems, know-how and intelligent systems, can cooperate with the Ljubljana Clinical Centre in various fields.
If you take, for instance, the work of the communication systems department, at first glance you would think that this has nothing in common with medicine, but that is not the case. Communication systems rely on the processing of signals, and signals in medicine are in fact the same – electrical biosignals – except that in the first case this involves the transfer of information via wireless links, and in the second case the transfer of information via live tissue, such as nerves or muscles.
Collaboration between the scientists in our department and the Clinical Centre was established ten years ago, specifically with the Clinical Centre's cardiovascular surgery staff, and special mention should be made of joint projects and the development of complex measuring apparatus to simulate cooling of the heart as well as the 64-channel measurement of surface ECG signals. Moreover our research has involved analysing heart signals in the human body and within the heart itself. We then established cooperation with the Neurology Clinic, in which we measure small changes in signals that result from the regulatory mechanisms in the human body such as ECG, breathing, pressure and so forth.
Staff at the electronics and information technology departments are technically educated experts with engineering skills in the fields of computing and electronics, while the Clinical Centre experts complement these skills with their expertise in medicine. We can therefore combine medical knowledge on the one hand with engineering on the other. There is therefore room for collaboration both in applied research and in jointly established pure research projects. This is also how we have worked together thus far. The results of our collaboration to date can be seen in the considerable numbers of measuring apparatus, clinical research, new procedures for measuring and processing signals and computer simulations, which in the majority of cases is clear from the joint articles in the professional literature. Our experiences indicate that together we can delve into research fields that would otherwise be inaccessible for each of us individually.



Asst Prof Dr Roman Trobec, representative of the electronics and information technology departments.

A further advantage that we anticipate from cooperation between IJS and the Clinical Centre is raising the quality of work. Physicians should gain more time to collaborate with us, which is important since currently too much work on joint research is pushed outside their and our working hours, frequently into the evenings, Saturdays and Sundays.
We anticipate that cooperation should also provide benefits for researchers at the Jožef Stefan Institute, and perhaps some advantages in the evaluation of joint research assignments. At the Institute we are expected to provide applied research, which is evaluated on the basis of financial contracts with industrial companies, and with financially defined terms of agreement. However, the research we conduct with the researcher physicians from the Clinical Centre has no financial definition, at least not for the moment, even though the research is both publicly applicable and publicly beneficial, and this should be appropriately quantified. In other words, when the agency came to assess such joint research by staff at the Jožef Stefan Institute and the Clinical Centre, it should place it, or at least the majority of it, in the category of public benefit.
The experts at the Jožef Stefan Institute have a great deal of theoretical knowledge and equipment, while the Clinical Centre physicians have their own knowledge and clinical experience. A great deal of the joint research is conducted on the basis of personal initiative and a belief in the importance of individual projects, but sooner or later the quality of work depends on the financing of individual research projects.
With high-quality joint research and research projects there is the ever-present issue of financing for these projects. What we desire is that such collaboration might also be supported by the Slovenian Research Agency, which currently separates medical research from natural sciences research, for instance through differing criteria for evaluating research results. Today we do not know what will happen when we act together, and we do not know whether this will be better or worse for the physicians or for us, since the issue of criteria has not yet been ironed out. In any event we anticipate and believe that the agency will encourage our collaboration.
Experiences at home and abroad undoubtedly indicate that computer technology is becoming increasingly important in medicine. Future cooperation between the two institutions with major scientific potential will be an increasing objective need, so we wish to collaborate even more with the Clinical Centre. Increasing importance will also be ascribed to treatment adapted to the individual, in contrast to what is for the most part today treatment of the "average" patient. Achieving this goal will require the use of computer simulation, in order for us to be able to envisage as far as possible the effects of various interventions on the individual patient. We anticipate that apart from anything else, in the future the Ljubljana Clinical Centre will become increasingly a research hospital. This kind of development will require the construction of a computer infrastructure, such as telemedicine, robotisation, equipping patients with various biosensors and monitoring their movement. In these fields the staff at the IJS electronics and information technology departments have a great deal of knowledge and experience, and for this reason they should also be involved in the future development of the Clinical Centre.

Dr Milena Horvat heads the environmental science department, and for the area of chemistry and the environment she has prepared a presentation on cooperation in progress and new prospects for cooperation:

This meeting between the heads of the Jožef Stefan Institute and the Ljubljana Clinical Centre is not merely the result of goodwill, but was in fact needed, since some very important changes are required in Slovenia to protect health and the environment.
At IJS we have expertise in natural sciences, while the Ljubljana Clinical Centre's expertise is in medicine, and if our goal is to do something for human health then we need to be well organised. Regarding the current collaboration I would say primarily that it arose on the basis of personal initiative from individuals and their continued cooperation in research projects, with research assignments being carried out thus far either under the aegis of the Ministry of Science or within the current Slovenian Research Agency. There has, however, been no systematic approach to this collaboration, something urgently needed and already established on the European Union level, such that recently we have been able to see how we are idling along behind such organisational improvements. I am speaking about the fields of the environment and medicine, for which on the European Union level in 2003 a strategy was adopted that provides a basis for creating tenders for thematic research assignments. This will also be included in the priority areas of the 7th Framework Programme.
Included in the fields highlighted at this meeting was nanotechnology, especially since the EU is ascribing great importance to this through tendered research projects, and in order to be involved in these projects, Slovenia must pool all its potential in this field. At IJS there are biochemists as well as scientists from other fields of chemistry who can join in this kind of cooperation, but of course successful work in these research assignments also requires medical expertise and knowledge from the field of biology. Furthermore we are still finding that we do not know how to link together with this knowledge into what is called the public dimension of this field, such that we might create an appropriate environmental and health policy. If we wish to make a quality leap, we must create the kind of targeted research programmes that will be supported financially. In other words, we also need politically accepted orientations, otherwise research projects will not just be limited in the best possible case, but even rejected.

Prof Dr Milena Horvat heads the environmental science department.

For our field it is also true that European money from the framework programmes alone will be insufficient. Several ministries within the Slovenian Government need to be involved: the Ministry of the Environment and Spatial Planning, the Ministry of Health and the Ministry of the Economy. The first test will be in directing the flow of finances from EU structural funds. This will require a systemic decision and adaptation to global trends, and I believe that joining the European Union has given us better prospects in this sense.
I also take the view that in Slovenia we will not know how to make use of available financing provided by the European Union via its tendered research assignments if we are not well organised within Slovenia. At the meeting we also talked about this, and several initiatives were tabled. What awaits us now is to make proposals that will draw our ministries to cooperate with us.
When we speak of cooperation on the level of institutions, I would also mention the cooperation between Slovenian researchers and the EU research centre at Ispra, which thematically covers everything in connection with health and the environment, and through a range of activities delves into the area of healthy food. Last year, representatives of the centre visited us at the Jožef Stefan Institute. We are due to return their visit. Of course these are not simply courtesy but working visits, and joint projects should be set up on the basis of initiatives from both sides, us and them, and here I can state simply that systematically established collaboration between the Ljubljana Clinical Centre and the Jožef Stefan Institute could provide both good ideas and the establishing of mixed research groups, which would ultimately be more easily incorporated into research projects. One such link in joint projects could therefore be with Ispra, with which, as stated, we are already collaborating.
There are indications of the possibility of joint research in the field of nanotechnology. I should also mention research in the area of neurotoxicology, where research involves numerous effects of the environment on the sensitive population group of newborn infants and children. This also involves studying the effect of substances on the nervous system, where we urgently require the collaboration of paediatricians and other fields of medical expertise.
A European Community project has been approved for the next five years that will involve 700 pregnant women and their children in Slovenia, primarily in the coastal area, around 700 in Italy, 200 in Croatia and 500 in Greece. This will be a major study. We talked about our cooperation in this project at the meeting with representatives of the paediatric clinic. We will also monitor the effects of large amounts of neurotoxic substances in children.

OF COURSE THERE IS STILL A WHOLE RANGE OF OTHER AREAS WHERE WE CAN LINK OUR KNOWLEDGE TOGETHER IN THE AREAS OF CHEMISTRY AND RADIOCHEMISTRY FOR THE REQUIREMENTS OF DIAGNOSTICS AND TREATMENT.

By Dragica Bosnjak,
DELO

Ervin B. Podgoršak, Recipient of the Coolidge Award from the American Association of Physicists in Medicine

"I would like to conclude my presentation with a Slovenian proverb that says: A healthy man has a thousand wishes, a sick man has only one. Most of the work of medical physicists is indirectly related to people who have only one wish. We must not forget that, despite our scientific and technical training, our strongest guiding attributes must be compassion for patients and discipline toward our work." With these words Ervin Podgorsak, PhD concluded his Coolidge Award acceptance speech in the awards ceremony during the 48th annual meeting of the American Association of Physicists in Medicine (AAPM) held in Orlando, Florida July 30 – August 4, 2006.

The Coolidge Award is the AAPM's highest honor, presented during the annual AAPM meeting to a medical physicist who has exhibited a distinguished career in medical physics in three areas: research, teaching and service, and who has exerted a significant impact on the practice of medical physics. The award is named in honor of William D. Coolidge, American physicist and inventor, educated at the Massachusetts Institute of Technology (MIT) and the University of Leipzig. During his 40-year career at General Electric, Coolidge became known as a prolific inventor and was awarded 83 patents. He is best known for the invention of ductile tungsten in the early years of his career. In 1913 he introduced ductile tungsten into x-ray tubes and revolutionized x-ray tube design with the use of the hot filament cathode as the source of electrons. Hot cathodes emit electrons through thermionic emission and are still in use today in x-ray tubes, now called Coolidge tubes, and in the electron guns of linear accelerators. In 1972 Dr Coolidge was the first recipient of the AAPM Award named after him.

The two sides of the Coolidge medal.

Dr Podgorsak is Professor and Director of Medical Physics at McGill University in Montreal, Canada. He was born to Slovenian parents in Vienna, Austria and grew up in Ljubljana, Slovenia. Four universities shaped his scientific, pedagogic and clinical careers, and he never forgets to stress that the first of these was the University of Ljubljana.

As stated in the recent Canadian Medical Physics Newsletter (July 2006), your 80-page curriculum vitae and the web-based information on the AAPM web site kept the authors of your profile quite busy. If we skip the years of your growing up in Ljubljana and your studies of technical physics at the University of Ljubljana, how did you make the transition from technical to medical physics?

The University of Ljubljana gave me excellent training in undergraduate physics, the University of Wisconsin gave me graduate physics training and introduced me to medical physics, the University of Toronto trained me in clinical physics, and McGill University allowed me to devote my professional life to academic and clinical medical physics. Medical physics is a very rewarding profession, combining one's love of physics with compassion for patients. There are about 15,000 practicing medical physicists around the World, of these about 6000 in North America. The AAPM was formed in 1958 and currently has almost 6000 members, 350 of whom practice their profession in Canada.

You state that your mother, who was widowed when you were 10 years old, instilled in you the understanding that the only way to succeed in life is through hard work and education. How did you use this view in your studies and professional advancement, and how did you deal with responsibilities in your own family?

I believe that this advice still holds true for everybody, and especially for young people. If they do not heed this truism, they may miss many opportunities for improving their quality of life and their position in society. I was lucky in my marriage, and my wife Mariana, with unequivocal support and an assumption of the lion's share in the upbringing of our two sons, made a large contribution to my academic and professional successes. One of our sons, Matthew, is also a medical physicist. He received his PhD degree in Medical Physics from the University of Wisconsin and works in Buffalo, New York. The second son, Gregor, received his BSc degree in Environmental Science from McGill University and works in Montreal.

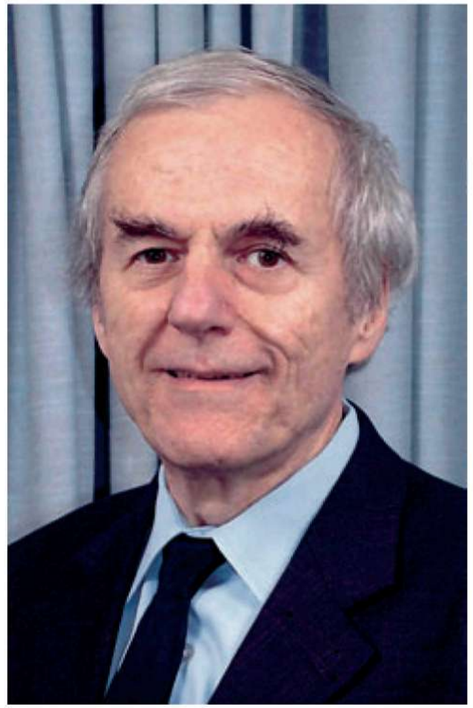
My entry into the world of science and clinical work was precipitated by an invitation from Dr Harold E. Johns to join his medical physics laboratory at the University of Toronto as a post-doctoral Fellow. At first I was involved in applied physics research, studying targets and flattening filters of high-energy linear accelerators used in cancer therapy, and later on I joined Dr John R. Cunningham's group at the Ontario Cancer Institute in Toronto to gain experience in clinical physics. Dr Johns received the Coolidge Award in 1976 and Dr Cunningham in 1988; thus, of the 35 Coolidge Awards given since 1972, three came to Canada and 32 were given to American medical physicists.

How is healthcare organized under the auspices of the renowned McGill University in Montreal where you have been working as director of the medical physics department in the McGill University Health Centre (MUHC) since 1979, as well as director of the Medical Physics Unit at McGill University since 1991?

The MUHC incorporates five McGill University teaching hospitals under one management organization and employs close to 10,000 people. The MUHC Medical Physics department provides clinical physics services to the hospital-based Radiation Oncology department, and the Medical Physics Unit is an academic entity at McGill University offering M Sc and Ph D degrees in Medical Physics.

Our clinical and academic medical physics services are integrated well, and the research carried out by staff and graduate students is of an applied nature. Often the research results are rapidly translated into clinical service that directly benefits patients. Our department is well known for the excellent collaboration between physicists and clinicians that resulted in many new cancer treatment techniques. Stereotactic radiosurgery is a good example. McGill University and Harvard University were the first North American institutions using radiosurgery based on clinical linear accelerators. Harvard used the so-called multiple converging arcs technique introduced a few years before in Buenos Aires, Vicenza and Heidelberg; McGill developed its own unique technique and called it dynamic stereotactic radiosurgery. We also introduced other techniques in radiotherapy treatment and radiation dosimetry, and this placed us on the forefront of medical physics in Canada as well as in North America in general.

The Coolidge plaque showing William D. Coolidge holding an x-ray tube based on his hot cathode design.



Ervin B. Podgorsak

You lectured on radiosurgery in Slovenia several years ago. What are the new developments in this accurate method for irradiation of brain tumors and vascular malformations located in critical brain areas not accessible by classical neurosurgery?

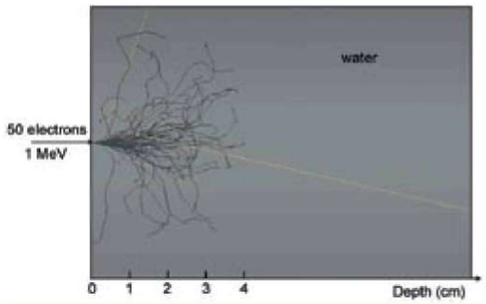
Radiosurgery combined with stereotaxy was developed in Sweden by neurosurgeon Lars Leksell in the early 1950s. Since then, three different types of beams were used for this purpose: protons from cyclotrons, gamma rays from so-called GammaKnives, and high-energy x rays from isocentric linacs. Proton radiosurgery started in the 1950s but proved costly and was practiced only in a few specialized centers around the world. It was supplanted first by the GammaKnife in the late 1960s and then by linac-based radiosurgery in the 1980s. We must note, however, that proton beams and even heavy charged particle beams are currently making a come back with several cyclotrons and synchrotrons being installed in major radiotherapy centers around the world for use in general radiotherapy, despite the relatively high installation and operating costs involved.

The GammaKnife incorporates 201 cobalt-60 sources producing 201 narrow gamma ray beams aimed at the machine isocenter. The machine is quite sophisticated technologically, but since it is dedicated solely to stereotactic radiosurgery, its purchase by standard radiotherapy or neurosurgery departments is difficult to justify. Nonetheless, the machine is commercially available and is installed in over 100 institutions around the world.

Over 20 years ago, it became apparent that the use of stereotactic frames and a few simple modifications to clinical isocentric linacs make linacs suitable for delivery of relatively inexpensive radiosurgical irradiation. Initially, the modifications consisted of special collimators that produced circular 1 cm to 4 cm diameter x-ray beams; subsequently specially designed miniature multileaf collimators (MLCs) were introduced. These developments made stereotactic radiosurgery widely available, and the technique is now considered a routine technique available in most major radiotherapy departments around the world. In comparison with the GammaKnife, the miniature MLC offers a simpler approach for accurate dose delivery to irregular targets within the brain as well as an option for intensity modulation, which is a recently introduced, exciting, linac-based radiotherapeutic technique.

Schematic diagram of the cobalt machine pictured on a Canadian stamp issued in 1988 by Canada Post in honour of Dr Harold E. Johns (1915–1997). (Photograph: Courtesy of the Canada Post Corporation. Reproduced with permission).

Dr Johns was a renowned Canadian medical physicist credited with the invention of the cobalt-60 teletherapy machine used for cancer therapy since the 1950s. Despite being eclipsed by the linear accelerator (linac) in the developed world, the cobalt machine is still the most important radiotherapy machine in developing countries due to its significantly lower capital, installation and operating costs as well as simpler operation in comparison with linacs.

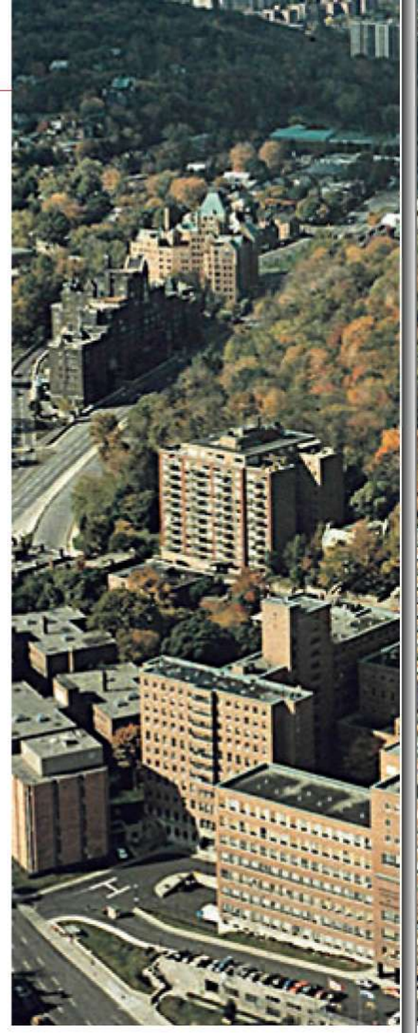


An electron pencil beam consisting of 50 electrons with a kinetic energy of 1 MeV penetrates into a water phantom. The distribution of electrons is calculated with the EGS-nrc Monte Carlo code that traces the trajectories of individual incident electrons through their various Coulomb interactions with the orbital electrons and nuclei of the water molecules. Interactions of incident electrons with orbital electrons result in collision (ionization) losses of the incident electrons; interactions with nuclei result in scattering (change in direction of motion) and may also result in radiative (bremsstrahlung) losses. The jagged paths in the figure represent incident electron tracks in the water; the two straight traces represent two bremsstrahlung photons, both escaping the phantom. A careful observer will also be able to discern the tracks of secondary electrons (delta electrons) that are liberated in the water by the primary electrons and given sufficient kinetic energies to be able to ionize matter in their own right.

(Photograph: Courtesy of Jan P. Seuntjens, PhD, McGill University, Montréal. Reproduced with permission).

Monte Carlo simulations played an important role during the recent AAPM meeting in Orlando with many presentations devoted fully or partially to this subject. What is the relationship between the Monte Carlo method and radiotherapy physics?

Monte Carlo calculation is a statistical process, and its accuracy depends on the number of events included in the calculation. The larger the number, the better the accuracy of the calculation and, of course, the longer the calculation time. With the ever-increasing power and speed of computers, Monte Carlo techniques are becoming of practical importance in radiation dosimetry and in calculations of dose distributions in patients treated with x-rays, gamma rays or particle beams. While the current treatment planning techniques are based on a set of measurements carried out in water phantoms, practical Monte Carlo-based treatment planning algorithms that are currently under development in many research centers will base the calculations directly on data for a particular patient, thereby, in principle, significantly improving the accuracy of dose distribution calculations. Patient-specific Monte Carlo-based treatment planning systems are already commercially available; however, their routine implementation in radiotherapy clinics still hinges on many factors, such as: (1) adequate modeling of radiation sources; (2) solving several experimental problems involving tissue inhomogeneities; (3) answering many important clinical questions; (4) updating the dose calculation algorithms; and (5) improving the computing hardware. It is expected that in the near future incorporation of predictive biological models for tumor control and normal tissue complication into Monte Carlo-based dose calculation engines will form the standard approach to radiotherapy treatment planning.



In addition to the GammaKnife and isocentric linac-based radiosurgery, we should also mention two other linac-based techniques that can be used for radiosurgery: the CyberKnife and the TomoTherapy machine. Both are based on a miniature 6 MV linac waveguide, mounted on a robotic arm in the CyberKnife and in a CT-type gantry in the TomoTherapy machine. The two machines deliver accurate treatment without the use of a stereotactic frame and can be used for treatment of intracranial as well as extracranial lesions.

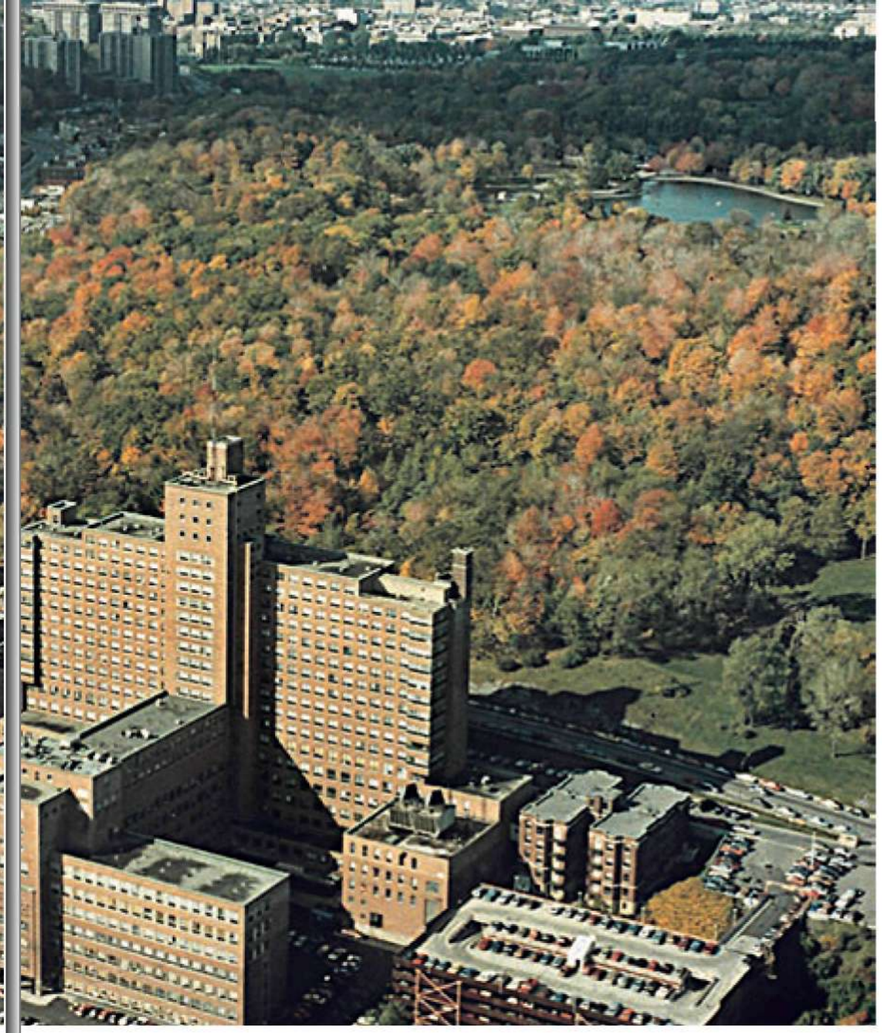
Medical physicists play an important role in the team of professionals delivering radiation to cancer patients. Would you briefly explain what medical physics is and what a medical physicist does?

Medical physics is a branch of physics concerned with the application of physics to medicine. It deals mainly, but not exclusively, with the use of ionizing radiation in diagnosis and treatment of human disease. In diagnostic procedures relatively low energy x-rays (diagnostic radiology) and gamma rays (nuclear medicine) are used; in therapeutic procedures most commonly high energy (megavoltage) x-rays and gamma rays or megavoltage electrons are used (radiation therapy also called radiation oncology or therapeutic radiology). During the past two decades medical physics has undergone a tremendous evolution, progressing from a branch of applied science on the fringes of physics into an important mainstream discipline that can now be placed on an equal footing with other more traditional branches of physics.

The study and use of ionizing radiation in medicine started with three important discoveries: x-rays by Wilhelm Roentgen in 1895, natural radioactivity by Henri Becquerel in 1896, and radium by Pierre and Marie Curie in 1898. Since then, ionizing radiation has played an important role in atomic and nuclear physics, and has provided the impetus for the development of radiology and radiotherapy as medical specialties and medical physics as a specialty of physics. The discovery of natural radioactivity triggered subsequent discoveries of artificial radioactivity by Frédéric and Ir ne Joliot in 1934 and nuclear fission by Otto Hahn, Fritz Strassmann, Lise Meitner, and Otto Frisch in 1939.

The potential benefit of x-ray use in medicine for imaging and treatment of cancer was recognized within a few weeks of Roentgen's discovery of x-rays. New medical specialties using radiology and radiotherapy evolved rapidly, both relying heavily on physicists for routine use of radiation as well as for development of new techniques and equipment. However, while radiology and radiotherapy have been recognized as medical professions since the early 1900s, medical physics achieved professional status only in the second half of the last century.

Initially most technological advances in the medical use of ionizing radiation were related to improvements in efficient x-ray beam delivery, development of analog imaging techniques, optimization of image quality with concurrent minimization of delivered dose, and an increase in beam energies for radiotherapy. During the past two decades, on the other hand, most developments in radiation medicine were related to the integration of computers in imaging, development of digital diagnostic imaging techniques, and incorporation of computers into therapeutic dose delivery with high-energy linear accelerators. Radiation dosimetry and treatment planning have also undergone tremendous advances in recent years: from development of new absolute and relative dosimetry techniques to improved theoretical understanding of basic radiation interactions with human tissue, and to introduction of Monte Carlo techniques in dose distribution calculations.



Montréal General Hospital, the largest of the McGill teaching hospitals which form the McGill University Health Centre (MUHC). The hospital is located in downtown Montréal at the foot of Mont Royal, the mountain that gives Montréal its name.

How does a medical physicist fit into the radiotherapy team and how is the team organized to gain the optimal treatment outcome for the patient?

It is well known that radiotherapy uses ionizing radiation to destroy cancerous cells. Essentially all malignant tumors can be eradicated with a large enough radiation dose; however, the problem associated with tumor dose delivery is in accessing tumors deep inside the body – a significant amount of radiation may be delivered to healthy tissues surrounding the tumor and this may result in acute or chronic complications and morbidity for the patient. The essence of radiotherapy, therefore, is to balance the tumor dose with the dose to healthy tissues, concurrently maximizing the tumor dose and minimizing the normal tissue dose. The higher the tumor dose, the higher the probability of tumor control; the lower the dose to surrounding healthy tissues, the lower the probability of normal tissue complications.

Accurate dose delivery to the tumor, of course, implies accurate imaging and target localization in three dimensions (3-D), as well as sophisticated treatment planning in 3-D in support

Isocentric linear accelerator (Varian, Trilogy) with an on-board imaging system for cone-beam CT. (Courtesy of Varian, Inc.)

TomoTherapy HiArt machine combining on-board imaging, patient positioning, 3-D treatment planning and dose delivery in a single system. (Courtesy of TomoTherapy, Inc.)

CyberKnife incorporating a miniature linac waveguide mounted on an industrial robotic arm for dose delivery and two orthogonal planar x-ray imaging systems for determination of target location. (Courtesy of Accuray, Inc.)

of the essential maxim of radiotherapy: "If you cannot see it, you cannot hit it; if you cannot hit it, you cannot cure it". To fulfill this basic principle effectively, the modern radiotherapy team consists of at least three professionals: radiation oncologist, medical physicist and radiotherapy technologist. The radiation oncologist determines the target volume, critical organs surrounding the tumor, and prescribes the total target dose and fractionation. The medical physicist is responsible for calibration of the radiotherapy equipment and calculation of the dose distribution in 3-D, as well as for ensuring that the radiation equipment is safe for the patient and staff. The radiotherapy technologist delivers the dose to the patient following the prescribed treatment plan, total dose and fractionation.

In addition to radiotherapy, medical physicists are also involved with medical imaging for general diagnosis of disease or specifically for target determination in radiotherapy. This imaging is carried out with: (1) relatively low-energy x-rays used in radiography, fluoroscopy and computed tomography (CT) scanning; (2) ultrasound; (3) nuclear magnetic resonance in magnetic resonance imaging (MRI); (4) gamma rays in gamma cameras and single photon emission computed tomography (SPECT); and (5) positron annihilation in positron emission tomography (PET). The majority of medical physicists currently work in radiotherapy; however, many newly graduated medical physicists now enter positions related to work with modern diagnostic imaging equipment such as CT, MRI, and PET.

TomoTherapy and CyberKnife sound like machines of the future, yet they are already commercially available. Could you briefly discuss these two futuristic machines and compare them to the standard linac?

The TomoTherapy machine was invented by Dr T. Rock Mackie and colleagues at the University of Wisconsin and uses a miniature 6 MV linac waveguide mounted on a CT-type gantry ring, allowing the linac waveguide to rotate around the patient. Beam collimation is accomplished with a computer-controlled multileaf collimator (MLC), also mounted on the rotating gantry. The MLC has two sets of interlaced leaves that rapidly move in and out of the beam to constantly modulate the intensity of the radiation beam as the waveguide rotates around the patient. During treatment, the table advances the patient through the gantry bore so that the radiation dose is delivered in a helical geometry covering the full target volume. The system is designed to obtain a megavoltage CT scan of the patient's anatomy at any time before, during or after treatment. The CT data are used for calculating the intensity of beam modulation that will result in an optimized dose distribution inside and outside the target volume and also provide an option for image guidance of the actual treatment. This image guidance allows fine adjustment of the patient's position at every treatment fraction to ensure that the dose distribution is delivered to the target volume precisely as planned.

The CyberKnife was developed as an innovative tool for frameless intracranial stereotactic radiosurgery, but its use has recently been expanded to treatment of extracranial targets. The machine delivers the dose with a miniature linac mounted on an industrial robotic arm, a combination that offers excellent spatial accuracy in dose delivery and allows a great deal of flexibility in directing the beam toward the target. Owing to its on-line planar target imaging and automatic adjustment of the radiation beam direction to compensate for target motion, the CyberKnife provides a frameless alternative to conventional radiosurgical procedures. The location of the target is pre-determined through a family of axial CT images that serve as a base for the determination of a set of digitally reconstructed radiograph images. During treatment, a set of paired orthogonal x-ray imagers determines the location of the lesion in the treatment room coordinate system and communicates these coordinates to the robotic arm, which adjusts the pointing of the linac beam to maintain alignment with the target and provides veritable image-guided dose delivery to the patient.

The TomoTherapy and CyberKnife machines are very sophisticated and cannot be used to replace standard teletherapy machines in routine treatments. They are, however, very suitable for treating certain types of tumors and complement well the standard armamentarium available in larger radiotherapy centers.

How does one protect the patient and staff from the hazards posed by ionizing radiation?

Soon after the discovery of x-rays and natural radioactivity it became apparent that ionizing radiation was not only useful for the diagnosis and treatment of disease but also harmful to human tissue. Two scientific disciplines evolved from the study of the effects of ionizing radiation on biological tissues: radiobiology combining radiation physics and biology and health physics concentrating on the study of radiation hazards and radiation protection.

When biological cells are exposed to ionizing radiation, the standard physical effects between radiation and the atoms and molecules of the cells occur first and the possible biological damage follows later. The biological effects of radiation result mainly from damage to the DNA, which is the most critical target within the cell; however, there are also other cites in the cell that, when damaged, may lead to cell death.

The effects of radiation on the human population can be classified as either somatic or genetic. Somatic effects are harm that exposed individuals suffer during their lifetime, such as radiation- induced cancers (carcinogenesis), sterility, opacification of the eye (cataract) and life shortening. Genetic effects manifest themselves as radiation-induced mutations to an individual's genes and DNA that can contribute to the birth of defective offspring.

The harmful effects of radiation are also classified into two general categories: stochastic and deterministic. A stochastic effect is one in which the probability of occurrence increases with increasing doses, but the severity in affected individuals does not depend on the dose (carcinogenesis and genetic effects). There is no threshold dose for stochastic effects because these effects arise in single cells and it is assumed that there is always some small probability of the event occurring even at very small doses. A deterministic effect is one that increases in severity with increasing doses, usually above a threshold dose, in affected individuals (organ dysfunction, cataract formation).

From left: son Gregor, grandson Anthony, grandson Alex, wife Mariana, granddaughter Kimberly, Ervin, son Matjaz and his wife Kristine.

It is obvious that ionizing radiation, despite its proven beneficial use in the diagnosis and treatment of human disease, must be used diligently and with care because of its potential for causing deleterious effects even at very low doses. Before any diagnostic or therapeutic procedure involving ionizing radiation is used on a patient, it must be established that the potential diagnostic and therapeutic gains outweigh the small, but not negligible, radiation risk associated with the procedure. As far as staff is concerned, strict national and international rules must be followed when installing, operating or servicing radiation emitting devices to ensure that staff exposure does not exceed prescribed limits.

What are the most notable recent developments in radiotherapy?

There is no doubt that the introduction of the CT-simulator and virtual simulation into radiotherapy services over a decade ago has triggered a greatly improved method for target definition and acquisition of patient data. This enabled reliable 3-D dose distribution calculations, a decrease of target margins and concurrent escalation of prescribed doses, all of which improved the outcome of cancer treatment with ionizing radiation. New treatment techniques, such as intensity-modulated radiotherapy (IMRT), have been developed on isocentric linacs equipped with multileaf collimators, and new machines, such as the CyberKnife and TomoTherapy, were introduced to allow unconventional dose delivery.

The IMRT technique is an advanced form of conformal radiotherapy with the objective of conforming the dose distribution to the shape of the target volume and resulting in increased tumor control probability and decreased normal tissue complication probability. The accuracy of dose delivery with the new techniques has been limited by uncertainty in target localization at the time of treatment. Interfraction as well as intrafraction target movement relative to reference landmarks coupled with set-up errors and other inaccuracies add to this uncertainty. The standard approach has been to add margins to the target volume, but this is done at the expense of most of the potential benefits of the more precise delivery techniques.

It has recently become possible to image patient anatomy just before delivery of a fraction of radiotherapy, thus gaining precise knowledge of the location of the target volume on a daily basis. This incorporation of imaging with dose delivery to the patient is known as image-guided radiotherapy (IGRT) and has the potential of ensuring that the relative positions of the target volume and the reference point for each treatment fraction are the same as in the treatment plan. IGRT thus allows reduced treatment margins, fewer treatment complications, dose escalation and the avoidance of geographical treatment misses.

Several IGRT systems are currently commercially available, all of them allowing pre-treatment imaging immediately after a patient is positioned on the linac treatment table for radiotherapy. Most notable of these are: (1) a kilovoltage or megavoltage imaging system integrated with an isocentric linac, referred to as cone-beam CT, (2) megavoltage CT with the TomoTherapy machine, and (3) on-line imaging with paired orthogonal planar imagers used in conjunction with the CyberKnife.

The next step in the full implementation of the IGRT is the concept of adaptive radiotherapy (ART) to correct for: (1) the interfraction changes in target volumes to account for tumor shrinkage, patient's loss of weight or increased hypoxia occurring during the course

of fractionated treatment, as well as (2) the intrafraction motion of the target to compensate for the effects of respiratory motion during the treatment. To account for organ motion during treatment, 4-D imaging technology is required, allowing the viewing of volumetric CT images changing over the fourth dimension, time.

With your own example, you presented the education and training required for entering the medical physics profession and you also alluded to the shortage of medical physicists. What would be of general interest in this regard from your Canadian and American experience?

Today's sophistication of modern medical physics and the complexity of the technologies applied to diagnosis and treatment of human disease by radiation demand a stringent approach to becoming a member of the medical physics profession. Currently, the most common path to a career in medical physics is an academic progression through a BSc degree in one of the physical sciences, but preferably in physics, to a MSc degree in medical physics and then to a PhD degree in medical physics from an accredited program in medical physics. The minimum academic requirement for a practicing medical physicist is a MSc degree in medical physics, and this level is adequate for physicists who are mainly interested in clinical and service responsibilities. However, medical physicists working in academic environments should possess a PhD degree in medical physics.

Academic training alone does not make a medical physicist. In addition to academic training, practical experience with medical problems and equipment is essential, and this may be acquired through on-the-job clinical training or, preferably, through a structured two-year traineeship, also referred to as an internship or residency program in a hospital, after graduation with a MSc or PhD degree in medical physics.

Many graduate programs are now available to an aspiring medical physicist, and progression through the three educational steps (undergraduate BSc degree in physics, graduate degree in medical physics and residency in medical physics) is feasible, albeit still somewhat difficult to follow in practice because of the relatively small number of accredited academic and residency programs in medical physics. The number of these programs is growing, however. We are now in a transition period, and within a decade, progression through the three steps will become mandatory for physicists entering the medical physics profession. The sooner broad-based didactic and clinical training through accredited educational programs in medical physics becomes the norm, the better it will be for the medical physics profession and for the patients the profession serves. In North America there is currently a shortage of newly trained medical physicists. The current output of accredited medical physics academic programs meets about 75% of the actual needs, while the accredited residency programs fare much worse, meeting only about 20% of the needs.

President of the AAPM Dr Russell Ritenour (left) and Ervin Podgoršak.

In connection with the education and training of medical physicists, I am pleased to see that the Physics Department of the University of Ljubljana is seriously planning to introduce an MSc program in medical physics. The general conditions for introducing this option are favorable, because the Physics Department, in collaboration with the Jozef Stefan Institute of Ljubljana and the Institute of Oncology of Ljubljana, has excellent equipment and qualified staff to allow the setting up of a world-class graduate program in medical physics. Of course, if the program aspires to attract foreign students, the lectures will have to be conducted in English. I have already seen the preliminary program, and I believe that within a few years the program should be able to acquire accreditation and a ranking among the leading medical physics programs around the world. Božo Casar and Vlado Robar, medical physicists from the Oncology Institute of Ljubljana, have already spent some time in our center in Montreal and Mr Robar received his MSc degree in medical physics from McGill University. In relation to contacts with Slovenian colleagues, I should add that a young Slovenian medical physicist, Dr Robert Jeraj, has a position as Assistant Professor at the University of Wisconsin in Madison. It would make a lot of sense to attract him back to Slovenia, since he could play a very important role in the nascent academic medical physics program to be introduced at the University of Ljubljana.

From your description of the medical physics profession I note that medical physicists are employed either by hospitals or medical schools, or hold joint appointments on the clinical as well as academic staff. This implies that the medical physics profession is influenced strongly by the healthcare model applied in a given country. How is healthcare organized in Canada and the U.S.?

The professional life of medical physicists is intimately related to the vagaries of healthcare management by governments and private organizations. Canadian and American healthcare standards are well respected around the world, yet in recent years it is becoming apparent that North American healthcare systems are not immune to the ills plaguing the healthcare systems of other developed countries.

There are three basic indicators upon which any healthcare system is evaluated: quality, accessibility and cost. In terms of quality and standards, it is safe to say that the healthcare systems in Canada and the U.S. are among the best in the world; however, in terms of accessibility and cost, the healthcare systems of both countries are in serious trouble. Actually, in comparison with the OECD healthcare indicators, Canada and the U.S. are below average on a number of specific and important indicators.

You mentioned the OECD. What role does the OECD play in healthcare?

OECD is an acronym for the Organization of Economic Cooperation and Development, an international organization of 30 countries that subscribe to the principles of market economy, pluralist democracy and respect for human rights. Its head office is in Paris, France, and its main contribution to modern societies is in providing a forum for comparing developmental indicators of individual member states and in coordinating, in a non-binding manner, domestic and international policies. The OECD group consists of countries from Western and Far Eastern democracies, as well as Turkey and several former Soviet bloc countries. Slovenia clearly meets all membership criteria, applied for membership in 1996, and is likely to be admitted in 2007. The OECD plays an important role in healthcare by issuing comparative statistics on the health status of member states' populations as well as on healthcare indicators for all member states.

It is surprising to hear that North American healthcare systems are in serious trouble. Why is this so?

The main problems with the Canadian and American healthcare systems are in their accessibility and sustainability. The two countries have similar social and economic systems, similar living standards and similar healthcare standards, but they differ significantly in the organization and funding of healthcare. Both countries use a mixture of private and public funding for medical services; however, the public share in Canada is at 70%, while in the U.S. it is only at 45%, allowing us to describe the Canadian healthcare system as publicly administered and the U.S. system as private medicine. Healthcare systems in both countries are relatively expensive: Canada spends 10% of its gross national product (GNP) on healthcare, compared to an 8.6% average for the OECD countries; however, several other countries, at 11% of GNP, rank above Canada, and the U.S. is in a league of its own at 15%.

The U.S. clearly leads Canada in availability of high-technology equipment and in timely access to healthcare, at least for the 85% of the U.S. population that subscribes to private medical insurance offered through employment or is ensured publicly through special programs for the aged or poor. On the other hand, in the U.S. some 45 million people (15% of the total population) have no health insurance and thus their access to healthcare is curtailed significantly. In contrast, all legal residents of Canada are covered through the nationalized healthcare system financed by the Federal and Provincial governments through general tax revenues. In comparison to the U.S., the Canadian public administration of healthcare delivery is more socially just and equitable as well as less expensive to administer; the administrative cost of the U.S. healthcare system stands at 25% of the total healthcare cost, compared to 12% in Canada. On the other hand, public administration in Canada is marred by chronic budgetary deficits, resulting in staff and equipment shortages, decreased productivity and waiting lists for non-emergency medical procedures.

Are there any useful lessons learned from the North American experience that can be translated to Slovenia?

In comparison to healthcare systems of economic powerhouses such as the United States and Canada, the Slovenian healthcare system is in reasonably good shape. On several healthcare indicators, such as the infant mortality rate, obesity rate and relative number of physicians, Slovenia is actually doing better than North America, and on most indicators it is close to the OECD average. Similarly to Canada, Slovenia is below the OECD average in availability of high-technology equipment, but this is to a degree understandable, since per capita expenditures for healthcare in Slovenia are only about 40% of those in Canada, and yet the price of high-technology equipment for Slovenian institutions is the same as that for an American or Canadian institution. Healthcare in Slovenia is financed through a payroll tax rate of 13.5% that covers 78% of total healthcare costs. Co-payments for many items in the mandatory package and voluntary supplementary insurance cover the private component of 22%.

Many interest groups and governments promote privatization as a solution to problems with healthcare costs and accessibility, yet it is not logical to surmise that a healthcare system run with a profit motive will be cheaper than an efficiently run public system. The U.S. private healthcare model clearly shows that privatization leads to inequity and high administrative costs. On the other hand, the basic principles of the Canadian healthcare system, enunciated in the Canada Health Act, can serve as a good role model for a nationalized healthcare system, since Canadian federal law prohibits co-payments as well as private coverage of publicly funded services. Unfortunately, during the past few years difficulties with public funding resulted in "creeping privatization" in Canada and the governments' reluctance to rigorously uphold the Canada Health Act.

Slovenia, with its small and socially conscious population, has an opportunity to develop its own healthcare system without the pitfalls of privatization. Health should not be treated as an ordinary commodity; like education, universal and timely access to good quality healthcare, regardless of citizens' ability to pay, should be a basic right of citizenship. This can only be achieved through an adequately funded, publicly administered and efficiently run nationalized healthcare system.

TABLE: A comparison of the Canadian, American and Slovenian healthcare systems with the OECD average. Data are from OECD: "Health at a Glance" and from "National Report on Health Care and Long-term Care in the Republic of Slovenia", June 2005.

	Canada	United States	Slovenia	OECD average
Health care cost as % of GNP	10	15	8.6	8.6
Health care cost per capita (USD)	3003	5635	1370	2307
Public share of total cost (%)	70	45	78	72
Physicians per 1000 population	2.1	2.3	2.5	2.9
Life expectancy at birth (years)	79.7	77.2	76.7	78.2
Infant mortality per 1000 live births	5.4	7.0	3.8	4.8
Population aged 65 years and over (%)	12.5	12.5	15	14

Forty Years of the TRIGA Reactor at J. Stefan Institute

By M. Ravnik

The TRIGA research reactor at the Reactor Centre of the Jožef Stefan Institute is celebrating its 40th anniversary, having started operations on 31 May 1966. The reactor has enjoyed 40 years of continuous operation with no failures of major components or any events violating safety standards. It was built by General Atomics (an American company), like more than 40 similar reactors around the world. In 1991 it was rebuilt and equipped for pulse operations. The technical condition of the reactor will allow it to operate for a further ten years, and it is planned to keep it operational at least until 2016.

To mark the anniversary we have set up a permanent exhibition on the 40 years of operation of the TRIGA reactor.

The TRIGA Mark II reactor is designed for training in reactor operation and technology, neutron research and isotope production. It is designed to be inherently safe, i.e. no operator error can damage the fuel or result in the release of radioactive material. If the reactor's power increases above the prescribed limit, the chain reaction will be shut down automatically due to the special properties of the fuel. In addition to its inherent safety, the cornerstone of the reactor's security is the qualified, experienced and dedicated staff.

The reactor generates approximately 50 litres of low and intermediate radioactive waste per year. At present, no highly radioactive waste is stored at the reactor, as all spent fuel elements accumulated during operation since 1966 were shipped to the USA for final disposal in 1999.

The practical results of forty years of reactor utilization are as follows:

Training

- practically all nuclear professionals in Slovenia have attended practical training courses at the reactor (including all professors of nuclear engineering and reactor physics at the universities of Ljubljana and Maribor, as well as directors and key personnel of NPP Krsko, the Slovenian Nuclear Safety Administration and the Agency for Radwaste Management);
- all NPP Krsko reactor operators and other technical staff are trained on the TRIGA reactor;
- the reactor is used in regular laboratory work by graduate and post-graduate students in physics and nuclear engineering from the Faculty of Mathematics and Physics at the University of Ljubljana;
- on-the-job training for IAEA trainees from developing counties (an average of two per year) is important for the promotion of the Jožef Stefan Institute and Slovenian science;
- the reactor has been used for several international training courses;
- it is open to visitors (over five hundred per year, mainly school children, come to see the reactor);

Guests at the anniversary celebration were greeted by the Minister of Higher Education, Science and Technology, Dr Jure Zupan and the Minister of the Environment and Spatial Planning, Mr Janez Podobnik.

Research

- the reactor has been used in research work published in some 300 scientific papers and more than 600 published conference reports;
- more than 20 PhD degrees, more than 30 MSc degrees and more than 100 first degrees have involved the use of the reactor.

Isotope production

- over 50,000 patients have been treated with radioisotopes produced in the reactor (mainly with radioactive technetium);
- 10–20 industrial sealed sources per year (mainly cobalt), totalling several hundred;
- several special radioactive sources (e.g. radioactive sodium in soluble compounds for turbine testing at Krsko NPP).

The TRIGA reactor has played an important role in developing nuclear technology and safety in Slovenia. For forty years it has been a centre of modern technology. Its international co-operation and reputation are

A round table discussion on the topic Use of the TRIGA reactor and the future of nuclear energy in Slovenia was led by Dr Matjaž Ravnik, director of the Reactor Infrastructure Centre at the Jožef Stefan Institute.

Dr Matjaž Ravnik demonstrated the operation of the reactor to the two ministers and the Institute's director Dr Jadran Lenarčič.

Staff showed guests the reactor and the laboratories of the Department of Environmental Sciences.

Jožef Stefan Institute

Fusion Research in Slovenia

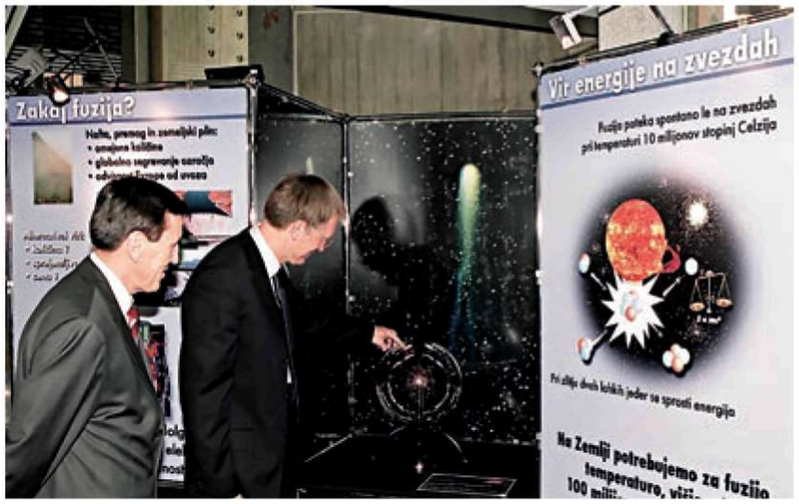
The Announcement of the International Thermonuclear Experimental Reactor (ITER)

By Saša Novak and Milan Čerček

site in south France, which came in June 2005 after long negotiations of the partners, was an event that increased not only interest in fusion research within the European research community, but has also thrown more light on the need for solving the problem of increasing energy demands and decreasing amounts of energy sources for the future.

Without doubt, the wellbeing of the world's population is closely connected to energy supply, and as a result the development and construction of fusion power plants is becoming a common global interest. It is for this reason that the international scientific and technological community has joined forces in an international fusion research programme, the second largest project after the International Space Station. The experimental fusion reactor, known as ITER, is going to be built within about the next ten years and will hopefully bring us closer to harnessing the power of a clean, safe and inexhaustible source of energy.

Until recently, fusion research was in the shadows and largely unnoticed, and the progress made over the past 50 years has gone to a large extent unnoticed. It is not, for instance, widely known that ITER is the follow-up to a significant number of tokamaks that have been constructed in a number of countries, and that it will be the predecessor of the demonstration power-plant DEMO, the last test device before a commercial power plant. With the site for ITER in Europe, there will be great opportunities for research institutions as well as for industry.



The Fusion Expo was honoured by a visit from the European Commissioner, Dr Janez Potočnik. He was guided at the exposition by the Head of the Slovenian Fusion Association, Dr Milan Čerček.

Slovenia in the European Fusion Programme

Slovenian scientists have long been collaborating in numerous fusion-related projects, so that the establishment of the **Slovenian Fusion Association**, SFA Euratom – MHEST (www.sfa-fusion.si) in March 2005 was very much the official act of joining Slovenia to the European fusion research programme, more than a start of activities. The primary mission of the SFA is to contribute to knowledge supporting the development of the future fusion reactor, but it also aims to improve public awareness of our energy needs, to increase the acceptance of nuclear fusion and to support the involvement of Slovenian industry in the construction of ITER. As its first action, the SFA organised, in collaboration with the European Commission, an exposition, **Fusion EXPO**, at Gallery TR3 in Ljubljana, where more than 2300 people had the opportunity to learn more about fusion – the background and potentials, as well as more about fusion research in Slovenia. After ten days of the exposition in the centre of Ljubljana, the exposition settled at the Reactor Center of the Jožef Stefan Institute in Podgorica. Every year, more than 8000 visitors to the Center, mostly secondary-school pupils, get a lot of information about energy needs and demands, and about the potential for fusion energy, the basics of the technology, and ITER.

The Slovenian Fusion Association, established on the basis of a contract between the European Commission and the Ministry of Higher Education, Science and Technology, is organised as a research group led by **Prof Milan Čerček**, who has been engaged in fusion as a researcher at the **Reactor Physics Department, Jožef Stefan Institute**, for many years. The major part of the research unit is represented by groups at the Jožef Stefan Institute, who are presently engaged in nine projects, strongly linked with the international community. Besides the departments at the Jožef Stefan Institute, the LECAD laboratory at the Mechanical Engineering Faculty,

The structure and operation of the ITER experimental fusion reactor was first demonstrated in Slovenia as an interactive model at the Fusion Expo in the TR3 Gallery in Ljubljana.

University of Ljubljana, and the associated, **University of Nova Gorica**, are also participating in the programme.

The fusion research programme in Slovenia

The contribution of the institutions in the Slovenian Fusion Association to several areas of the fusion programme are based on the R&D experience of the researchers in the fields of nuclear, atomic and plasma physics, materials science, mechanical engineering and computer-aided design. The major equipment available in the institutions includes an ion-beam accelerator with material diagnostics installations, the TRIGA reactor, high-temperature furnaces, an advanced, dedicated fully-integrated high-resolution microscope facility for investigations of nanostructured materials, computer systems for simulations, structural mechanical analysis and CAD, and much more.

Structural materials have been established as the key factor in realising the economic viability of fusion power, full operational safety and low environmental impact. Hence, one of the primary goals of the fusion research programme is to develop suitable materials. For the economic exploitation of the fusion reaction, a severe temperature regime will be encountered, and hence only materials with specific compositions and behaviour will be suitable. The development of a material that will meet all the demanding requirements for the structural application in the first-wall blanket (gas-tightness, highly reliable high-temperature mechanical properties, etc.) is a challenging task for scientists. There is a very short list of candidate materials, among which the most promising is a composite of a SiC-fibre textile infiltrated with a low-activation SiC-based matrix material, SiCf/SiC. A group of materials scientists at the **Department for Nanostructured Materials (Dr Saša Novak,** Dr Goran Dražić) is focused on ceramic processing for the production of low-activation SiC-based composites.

The researchers at the **Department for Low and Medium Energy Physics** study the processes that occur on plasma facing materials and in the edge plasma of tokamak reactors and involve neutral hydrogen/deuterium molecules. These molecules are typically vibrationally excited, which influences the respective reaction cross-sections. The group, led by **Dr Iztok Čadež**, has developed a special experimental technique for the vibrational spectroscopy of molecules and also uses the ion-beam analytical technique ERDA to characterize the hydrogen content on and beneath a material's surface. The investigations are performed in neutral test atmospheres with vibrationally excited molecules as well as in a plasma environment in the linear magnetized plasma machine in the **Plasma Physics Laboratory** (Dr Milan Čerček) of the **Reactor Physics Department.** Another study in the department (**Dr Primož Pelicon**) focuses on ion-beam analytical methods for studies of plasma-wall interaction processes, such as erosion, deposition, fuel retention and material migration in fusion reactors. The relevant specimens from the experimental fusion reactor TEXTOR in Germany, including probes, tiles, co-deposited flakes, microbalance crystals and limiters are analyzed.

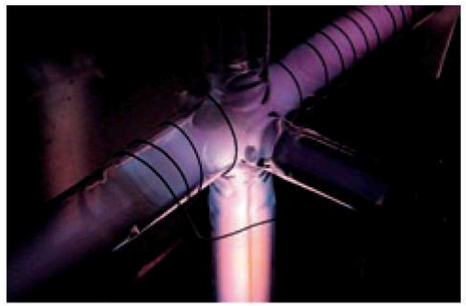
In the **Department for Surface Engineering and Optoelectronics** researchers are engaged in two fusion-relevant projects. The first, led by **Dr Miran Mozetič**, deals with an investigation of the surface recombination of hydrogen

A group of researchers from the Department for Nanostructured Materials, engaged in the development of ceramic composites for the first wall in a fusion reactor: Dr Saša Novak, Dr Goran Dražić and young scientists Katja Mejak and Tea Toplišek by the transmission electron microscope.

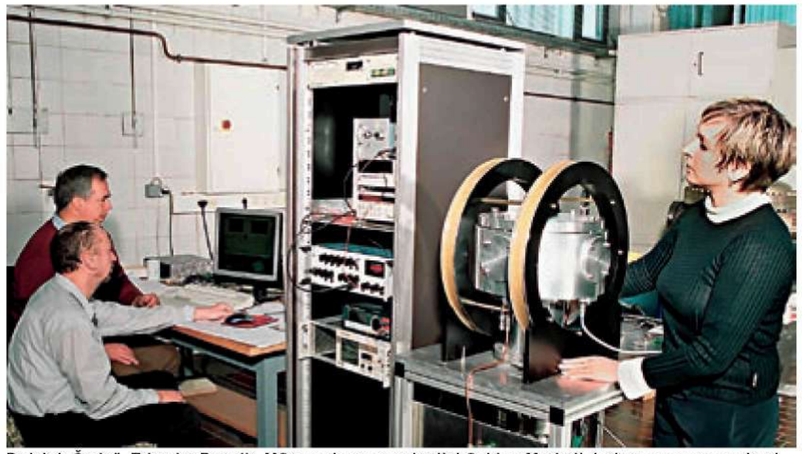
Dr Igor Lengar, Luka Snoj, Dr Matjaž Ravnik and Dr Andrej Trkov examining the results of the calculations of neutron attenuation for a new gamma-ray camera at JET.

Dr Tomaž Žagar introducing a ceramic sample into the irradiation channel in the TRIGA Mark II.

atoms on fusion-relevant materials, with the aim to create a reliable database of recombination coefficients. A precise determination of the coefficients is not possible without knowing the atom density, and for this purpose a new probe has been constructed. It makes use of a catalytic recombination process on the probe-tip surface. The objective of the second project (Dr Vincenc Nemanič) is to study and quantitatively characterize the kinetics of the deuterium interaction with the reactor wall material. Precise pressure-gauge measurements and quadrupole mass spectrometry of the up-taken and released gases are utilized in the study. A better understanding of the deuterium interaction will also help to predict tritium retention and the decommissioning kinetics more accurately.



Plasma device for studying the atomic hydrogen interaction with materials.



Dr Iztok Čadež, Zdravko Rupnik, MSc, and young scientist Sabina Markelj during measurements at the spectrometer for vibrationally excited hydrogen molecules.

The world's largest experimental fusion reactor at present, JET, is equipped with a great deal of diagnostic instrumentation, including gamma-ray spectrometry and imaging. The present systems have components that are quite old and difficult to support. A number of upgrades are required to preserve JET's diagnostic capability and to improve the quality of the measurements. In particular, by using appropriately chosen neutron-attenuating materials to reduce both the neutron background and the neutron-induced gamma-ray background, the measurements of fast ions and -particles could be performed in JET's discharges. A group of researchers at the Reactor Physics Department under the leadership of **Dr Igor Lengar** is responsible for neutron-photon transport calculations, the evaluation of attenuation factors and neutron in-scattering effects within this JET-diagnostics upgrade project.

Several types of blanket modules for ITER are being developed within the European fusion programme. A specific project, the sensitivity/uncertainty pre-analysis of a mock up of the test-blanket module based on the HCLL concept is performed in the same department in order to assess the uncertainty about the tritium production ratio resulting from the uncertainty in the basic nuclear data. The researchers, including **Dr Andrej Trkov**, use deterministic transport codes, a special sensitivity/uncertainty code package and libraries during their work. Sensitivity profiles and nuclear data uncertainties, which will be determined for the neutron responses, will be used to guide and optimise the design of the benchmark experiment.

Besides the research aimed at supporting the development of JET and the ITER, the Jožef Stefan Institute also takes part in the design of more "distant" fusion power-plant reactors. **Dr Matjaž Ravnik** from the **Reactor Physics Department** is a member of the DEMO Working Group. The main objective of his collaboration and participation is contributing to topics related to conventional nuclear power-plant technology, in particular to topics related to nuclear safety and nuclear-waste treatment. One of them, a review of the report on the categorization of activated material, prepared as the basis for various power-plant conceptual design alternatives, has already been investigated.

The LECAD laboratory at the University of Ljubljana (Prof Dr Jože Duhovnik), has been chosen as a partner to provide an insight into the design problems of stellarator Wendelstein W7-X, another type of toroidal fusion device. The results of the analysis pointed to potential problems by providing an insight into zones of excessive plasticity, which might lead to fractions or collapse of the structure. LECAD currently continues to provide engineering solutions for Wendelstein W7-X by performing additional parametric analyses of the supports in new projects. LECAD also designed and manufactured new tools for the manufacturing of the vacuum vessel sectors of ITER.

The areas of the fusion programme of the SFA:

- plasma-surface interaction in ITER-relevant conditions
- integrated tokamak modelling
- development of nuclear diagnostics for JET
- development and irradiation testing of new ceramic materials for fusion reactors
- analysis of TBM neutronics experiments and validation of EFF nuclear cross-section data
- development of special tools for the construction and production of ITER parts
- structural mechanical analyses and evaluations to support the ITER and Wendelstein 7X projects
- collaboration in the DEMO Working Group
- fusion-related experimental methods at the TRIGA Reactor

20 Years of the Science Supplement in the Newspaper DELO

Credibility is the Key for Us

By Boris Čerin

It is generally the case that leading national newspapers build their image on correct reporting, which in view of the complexity of the various events in the majority of today's societies is demanding and responsible work. You have to be up to the task, or in terms of individual journalists, they must be capable of analysing comprehensibly the issue they are presenting to the reader. Nor can we forget the reader's trust. This trust is conditioned to a great extent by the overall image of the individual newspaper and how readers sense the individual newspaper. And this brings us to the entirety. An overly narrow orientation puts off the more demanding reader. For this reason leading newspapers like to show that no subject is too difficult for them and that they can delve into all fields – including science, which readers take to be the most difficult of all.

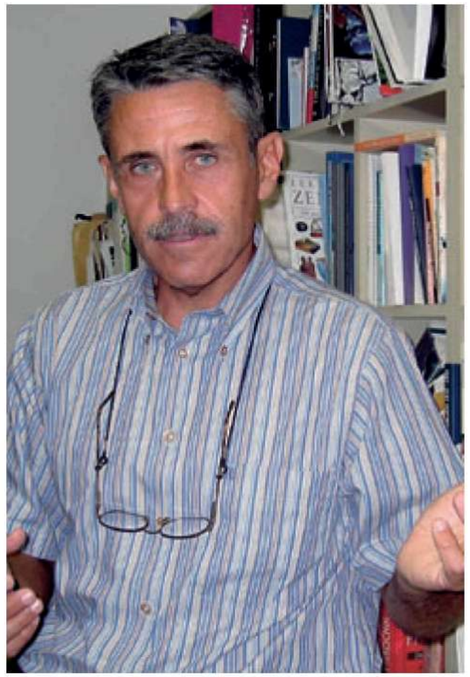
Of course a point such as this is just one aspect of the whole. Science delves into so many areas that affect us, that is, each individual, that there most certainly exist a whole range of topics that might draw our attention. It offers much fascination. Yet we quickly face a dilemma of what form of reporting and writing about scientific achievements is most suitable for the individual newspaper. And this is the area covered by the individual editor.

At the most eminent Slovenian daily paper, ***Delo***, responsibility for this lies with Gregor Pucelj, editor of the weekly supplement ***Science*** [***Znanost***]. He talked to us for this article.

Gregor Pucelj, editor of the weekly supplement ***Science*** [***Znanost***].

QUARK: We might say that over the years the Science supplement has been formulating its appearance. What was going on in the initial thinking? The readers, most probably. And a sufficiently wide circle of correspondents?

PUCELJ: Our supplement, which was then called Znanje za razvoj [Knowledge for Development], first came out precisely two decades ago, on 30 September 1986. There was simply a growing awareness and need at that



Gregor Pucelj, editor of the weekly supplement ***Science*** **[*Znanost*].**

time to offer our readers some rather more expanded and in-depth information on developments in the widest area of science, technology and medicine. Others were aware of this, too, since "science" supplements started appearing with other outstanding daily papers, such as The Guardian and The New York Times.
Ultimately of course it was also a time – whether or not we were socialist or capitalist – when researchers gradually started being aware of the need to communicate with the widest possible audience. There was gradually sharper scrutiny over the issue of financing the wide variety of research programmes, and the public demanded explanations and answers about what taxpayers were putting their money into... Of course this did not come easily or overnight. At first researchers found it hard to reveal the secrets with which they were dealing. But when they started to realise that they had to open up to the public, we ran into another problem – they did not know how to explain simply what they were doing and what new things they had discovered.
It was here that the positive side of a supplement such as ours was demonstrated. On the one hand we were educating readers to keep abreast of domestic and foreign research achievements. On the other hand – and this is still an important part of my work today – we were teaching the researchers how to write simply and comprehensibly. And believe me, this was not easy, at least for the first few years.

QUARK: The simple transfer of the practices of leading world newspapers was probably not the ideal thing, since in Slovenia we have our own peculiarities.

PUCELJ: Exactly. Owing to some of our peculiarities – we have a relatively small research community that goes with the small size of the Slovenian population – we have to balance up differently the great research and technological achievements and events that are taking place on the global level and chiefly in the research superpowers such as the USA, Japan, the UK, Germany and France with domestic developments "taking place" in our research institutes, laboratories and industry. Here we stick to the simple rule of journalism: writing about the consequences of a small flood in the local environment is much more important than a tsunami in another part of the world. In the figurative sense, of course.
Of course we are also lucky in that many Slovenian researchers are also working successfully abroad. In today's world of the Internet and e-mail we are thus right up to date on what they are doing and of course we are also writing about this.
Yet there is at least one other peculiarity that distinguishes us from similar supplements in the "big" world papers. That is language. The point is, we live in a time when English is relentlessly conquering the world – especially in the research community. So on the one hand we have a limitation, whereby we have to translate everything that is accessible on the extremely numerous sources of information. On the other hand we have the advantage and mission of cultivating and promoting the development of popular "scientific" Slovenian. This is not always easy, since some researchers' terminology has succumbed entirely to English, and they do not know how to "translate" it into Slovenian. Still, through joint efforts we ultimately always succeed.

QUARK: Adapting to the needs of readers has influenced editorial work. Have the readers' demands changed much over the years?

PUCELJ: Mainly the readers have less and less time and patience. They receive the majority of information via electronic media in effect as soon as it happens. So newspapers such as ***Delo*** and especially a supplement such as ***Science*** find themselves in a schizophrenic situation. On the one hand we are aware that we must publish shorter articles carrying a wealth of pictorial material, thereby "making" television out of a newspaper. On the other hand we are also aware that our readers are not entirely ordinary – in our supplement they expect a slightly more in-depth explanation of what they caught in passing on the radio or television. So we combine. We print many things as briefly as possible, but we give a thorough treatment to more interesting topics, even if this means the article runs to over half a page. Such hot topics now are for instance cloning, climate change, astronomic discoveries and similar.
But the fact is that we are becoming increasingly a "picture book" with shorter and shorter texts. This is most obvious if I look back at old issues of ***Science*** from 10 or 15 years ago and compare them with what we have now.

QUARK: Tell us about your cooperation with the correspondents, or rather the experts in various fields who are published in your columns. In the years that you have been editor, the circle of external contributors has probably increased. Are the scientists and experts in various fields becoming increasingly proficient at writing?

PUCELJ: It is undoubtedly quite different today and – at least for me as editor of ***Science*** – much easier than it was in the first years. Researchers, university professors, doctors and engineers have got used to reporting and writing about their work and achievements in our supplement. Here we combine our own, in other words journalistic, writing – for the most part interviews – with articles and commentaries written by the "actors", in other words the researchers themselves. In this way around 200 external writers are featured on our pages in one year. Some of them are by now fairly permanent contributors who write several articles each year, since they report on new features from their field that have emerged for instance on the world level. Others write exclusively about their own work. In this way every Thursday we fill 3-4 pages of ***Delo***.
There are of course major differences between writers. Technologists in particular frequently find it harder to formulate popular texts that are not riddled with figures and tables. But things have improved over time. They have got better and better at heeding my advice. I can offer praise especially to the younger researchers and experts in general who tend to write better than their older colleagues.
It is also perhaps at least evident in some way that in many environments increasing attention is paid to what is called public communication. Younger researchers also participate in workshops organised several times a year by the Slovenian Science Foundation, at which I myself speak a little about my experiences.

QUARK: You are assisted by four other journalists in your editorial office. Are you a good team?

PUCELJ: There are actually five of us altogether in the editorial office at the moment, and of course we also cover current events in the area of research policy and international developments, about which we write in the regular columns of the paper and in the ***Saturday Supplement***. Over the years my colleagues have also become specialists in individual fields, and they can easily get to grips with the most demanding subjects. But this is frequently "bloody" work ... Although in the paper, where the text flows nicely and everything is in its right place, the reader does not notice that at all.
With a few minor changes we have been together quite a number of years, so we know each other well. As editor I know what is right for each of them and what I can entrust them with. But of course this inevitably involves the usual tensions where the deadline for submission of material has passed and the articles have not even all been written. But that's the daily fare of journalism.

QUARK: Do you get reader responses?

PUCELJ: To be honest, not a lot. I can explain. People's nature is simply that if everything is all right, we are happy not to react. So occasionally I receive some thanks from external writers for a well edited article, and here and there some proposal or suggestion about what would be good to write about. But of course I immediately get a response if there is something wrong, if we produce some misprint – or rather, some mis-compute. Luckily, however, we are only rarely troubled by this.
Of course we monitor the readership level of the whole newspaper and of our supplement in different ways. These are extensive analyses that we carry out every few years. In the last one – I think this was just under two years ago – the ***Science*** supplement came out surprisingly well. Naturally we are far behind the readership level of the Saturday Supplement, whose political and economic topics make it the flagship of the newspaper, but we have overtaken the literary supplement (**Književni listi**), and even the Monday sports supplement and the motoring supplement. Clearly research achievements interest increasing numbers of readers. So it is with moderate optimism that we are embarking on the next two decades, if I might be facetious. Of course we must constantly be aware that around the world there are not many comparable major newspapers with a print run of 70,000 to 90,000 that could demonstrate such interest in science, and I hope that in our case it will remain so.

QUARK: And you have even received some awards for your mission ...

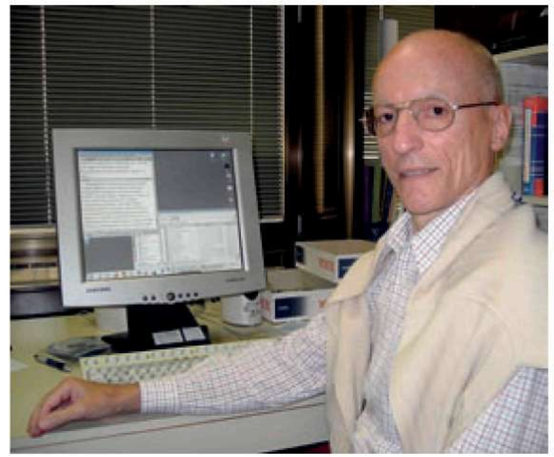
PUCELJ: Yes, in 2003 the Slovenian Science Foundation declared us to be a Prometheus of Science for "developing communication about science in the main Slovenian daily paper." This was followed in 2004 by our ranking among the finalists for the Descartes Prizes 2004 – Excellence in science communication, which the European Commission had organised for the first time also in recognition of communication on science. We were in the august company of figures such as Sir David Attenborough, the universally known voice (and face) from the legendary series on science that the BBC has been producing since 1954. In the end he won the main prize.

QUARK: Given that other newspapers in Slovenia cannot provide scientific coverage on the same level as ***Delo***, is this actually in the national interest?

PUCELJ: Those are rather strong words. Of course our supplement – I think primarily with credibility – plays a certain role in Slovenia. As I have said several times before, we are a bridge between the research sphere and the general public. This was the vision that was adopted back in 1986 on the founding of the supplement by its first editor, Silvestra Rogelj – Petrič, and we are faithfully pursuing that.

Jasna Kontler Salamon

Dragica Bošnjak



Tomaž Švagelj

By Dragica Bošnjak
DELO

Interview with Dr Miroslav Polzer, director of the Austrian Scientific Institute in Slovenia

Where Is the Dividing Line Between the Local and the Global in Science and Ethics?

The content and background for this interview with Dr Miroslav Polzer, director of the Austrian Scientific Institute in Ljubljana, could, with a little imagination, be expressed by a geometric shape and a mathematical formula. It is "a sort of triangle" symbolising years of efforts to improve scientific and research cooperation between Austria, Slovenia and the Western Balkans, with the latter covering the countries of the former Yugoslavia "minus Slovenia, plus Albania".

To make understanding easier, this is the simplest way to outline the activities of the Austrian Scientific Institute in Ljubljana which cover this part of the Balkans. This is an area which "on maps and in name" is still where it's always been, but, as we know, in different historical periods they have experienced dynamic changes and, equally, (non-)identification with the term Balkans, be it south-eastern, western or any part thereof.

Dr Miroslav Polzer, director of the Austrian Scientific Institute in Ljubljana.

Ljubljana, Sofia, Brno ...

There are very diverse forms of cooperation among Vienna, Ljubljana and various Balkan countries or across the wider area. They are presented in more detail in a special publication of the Vienna Centre for Social Innovation and involve, for instance, expanding the information society, rapid transfer of academic knowledge and achievements into practice, the creation of centres of excellence and the formulation of priority development guidelines, and they strive for the social integration of migrants and threatened ethic communities in various European countries, among other activities mentioned by the interviewee. Another point of interest worth mentioning is that the Austrian Scientific Institute in Ljubljana cooperates closely with the institutes of the same name in Sofia in Bulgaria and Brno in the Czech Republic; the basic activities of all three institutes have since 2004 – with emphasis on a partnership approach – been coordinated by the Vienna Centre for Social Innovation, which comes under the umbrella of the Austrian Federal Ministry of Education, Science and Culture.

Openness to other cultures

Dr Miroslav Polzer and his colleagues in Ljubljana have been active for over a decade. Extensive publicity activities and other professional symposium-conference documentation confirm that this has been a success. The fact that he knows conditions in the region we are discussing very well is confirmed by several favourable circumstances: personal involvement, excellent education and, last but not least, his origins. He is a Carinthian Slovene, which he is pleased to emphasise whenever our discussion turns to the fact that in his work he is split between Vienna, Ljubljana and Sankt Primus in the municipality of Sankt Kanzian by Klopeiner See, where he was born and where his parents still live, and his home close to Bleiburg, where he goes two or three times a week. "Well, you can get there in less than two hours. My job's in Ljubljana, but my family's there ...". But because since the almost daily travelling his job involves is also part of his nature, openness and interest in the lives of other people, cultures, customs and the possibilities of socio-economic and particularly scientific development in environments that until now have had insufficient opportunities, or that did not pay enough attention, this represents a constant challenge.

Work which is also a hobby and a lifestyle

"If I didn't have to worry about money and had a little more time," he says, "I'd do this for pleasure, as a hobby, as it's so interesting." Of course, a great deal of enthusiasm is always needed, since his work is tied to a one-year contract with the Austrian Ministry of Education, Science and Culture, and more specifically the Centre for Social Innovation. He therefore has to continually prove himself, justify his existence with interesting ideas and programmes. Good programmes need to be prepared all the time, financiers must be convinced, and of course those expecting financial support must be helped with advice – young researchers, scientists, representatives of nongovernmental organizations in the region, participants in international scientific meetings ... Individuals or groups reply to tenders or themselves propose different options for scientific cooperation with the Austrian Scientific Institute in Ljubljana, either in the Western Balkans or in the joint European research space.

If you're from the margins, you have to prove yourself twice ...

A fleeting glimpse of his CV and a chat about his early childhood shows that living in a bilingual area, recognising minority problems and later different education streams, as well as involvement in charitable activities, have brought valuable life experience, particularly useful in his current work, although at first sight it doesn't have a great deal in common with varied scientific activities. From his own experience he better understands disadvantaged individuals or groups from environments where it is difficult to escape deep-rooted prejudices and preconceptions of inferiority. Here though, as we can conclude from the conversation below about stereotypes and prejudices linked to the level of science and research in certain underdeveloped regions, an excessively sentimental emphasis on inclinations and understanding the deprived would be of no use if it were not linked to a realistic critical assessment of the situation and mutual involvement ... More specifically: in life, some people – whether they are school pupils, students or young researchers from certain, less developed environments – have to work harder for success and to prove themselves, compared to others from more favourable environments. As there is no suitable infrastructure, understanding, investment in knowledge and innovation, exceptional personal engagement, persistence and courage are required. And such competition – where some have advantages right from the start, or at least appear to – can be painful and can seem unjust. But this is the inevitable reality that must be faced. Even more specifically and topically: that the "mother EU" should take in its arms – as it knows what order is and how to arrange things – the queue of "kids" knocking at the door who will have to prove that they deserve it. That they are capable, have the knowledge, will, ideas, strength. That they will not, in short, be the spanner in their development works ...

And as for what future EU members will have to do in order to achieve faster development, primarily through investment in human resources, science and research, and how the more developed EU members can help them achieve this, that will come a little later. The conversation on his education and early life experience is interesting as it confirms what we already mentioned – great personal engagement in order to make the breakthrough, prove himself, find himself and succeed.

From distinction in the baccalaureate to a world of varied experiences ...

His education included four years at the Slovenian grammar school in Klagenfurt, a baccalaureate with distinction at Klagenfurt College of Telecommunications and Electronics, a degree in economics and business with an emphasis on information sciences and banking, a doctorate at Graz University on environmental problems in Calcutta, postgraduate study in technical environmental protection ... also, partly in relation to the doctorate, and partly due to civilian service with the Red Cross in Völkermarkt, some volunteering experience in India and Nepal and work with Karitas, all of this has helped expand his life horizons. Even as a student as well as later he worked with the Austrian bishops' conference, the umbrella organization for other organizations dealing with aid for developing countries, serving as coordinator for activities and know-how transfer to the countries of central and eastern Europe. Afterwards, he worked in the Prosveta house in Tainach, which is an educational institution for Carinthian Slovenes, as a teacher in the areas of environmental protection, cooperation with developing countries and European integration. Then in January 1996 he came to the post he currently holds at the Austrian Scientific Institute in Ljubljana. But here he didn't start from scratch, he inherited the good start developed over six years by his predecessor and founder, Feliks J Bister, also a Carinthian Slovene, the first director of the institution, which was initially named the Ljubljana branch of the Austrian Institute for Eastern and South-Eastern Europe.

At first, this involved more support for bilateral cooperation between Slovenia and Austria, but the focus has for some time now been on connecting scientific capacities in Austria and Slovenia – involved as partners – with scientific potential in south-eastern Europe, and particularly those countries defined by the European Union as the western Balkans, that is the countries of former Yugoslavia and Albania.

Continuing the good inheritance from his predecessor

As Dr Polzer says, his predecessor had already undertaken important work, when in the early years of the institute, with the cooperation of Austrian historians and other scientists from the humanities, he managed to illuminate certain problematic themes, such as Germanisation, German dominance of the Slovenian nation and the like, as multilaterally as possible and to shift

the debate from the emotional to the scientific level, which is important for a realistic image and in looking to the future.
In the last decade or so and since Slovenia joined the EU, the institute – in the manner described above, i.e. partnership of two neighbours – has strived to transfer know-how regarding European integration and numerous related issues. The Austrian Scientific Institute has among other things been heavily engaged in the organization of various professional meetings, one of the most prominent of which was Science and Society in an Expanded EU, held in the Slovenian Parliament; through this international conference, they wanted – in conjunction with the Slovenian Science Foundation and the National Council – as the title suggests to establish the significance of science for the development and stability of Slovenia and the European Union. As tolerant inter-ethnic relations and an inclusive multicultural society are important preconditions for the success of the "United Europe" project, the conference also presented the ethnic project, the aim of which is to inform members of national minorities of the possibilities in the area of science and technology and to support them in their equal participation in society.

Partnership cooperation with the Balkan countries

One important event that should certainly be mentioned is the conference last year in the European Parliament, also on the theme of participation by Western Balkans countries in current and future European Research and Technological Development Framework Programmes (EU RTD-Framework Programmes). This forum was jointly organised by the Slovenian Ministry of Higher Education, Science and Technology, the Austrian Ministry of Education, Science and Culture, and the Greek Ministry of Development together with the European Parliament, and also involved representatives of the Austrian Scientific Institute. The meeting was supported with active participation by science and research commissioner Dr Janez Potočnik and brought together representatives of ministries of the countries of Southeastern Europe. Similarly, we should mention last year's symposium on the questions of religion and European integration, while this year we have the scientific meeting in Vienna entitled "Slovenia and Austria as Partners in Relation to the Western Balkans,"

Dr Miroslav Polzer, director of the Austrian Scientific Institute in Ljubljana.

Tolerant in dialogue with the help of science, including on "hot" topics

As Dr Polzer explains, they are not afraid to "pull someone else's chestnuts out of the fire", that is, they do not avoid problematic themes which actually call for a scientific approach so as to find in a tolerant and cultured dialogue suitable practical solutions for better solutions to, for instance, minority issues, cultural heritage, modern migration, the status of the Roma. In connection with the last of these, Dr Polzer recalls that in cooperation with the Institute of Nationality Issues and others, they significantly contributed to raising awareness of their status in various countries. It seemed that the Roma question is one of the central minority issues in the European Union; in the expanded EU, the Roma are one of the largest ethnic groups, and are very heterogeneous practically everywhere. It is therefore very important that countries cooperate with each other and of course with the Roma in regulating their status. In some places, Roma communities have greater opportunities for active participation and suitable integration into their environments, but in many places they remain trapped in a vicious circle of marginalisation, always on the edge. Sometimes, though, all that is needed is to look around and exploit the opportunities that exist. Thus, for instance, experts from the University of Graz, together with Slovenian colleagues specialising in Roma issues, found that the autochthonous Roma population in Burgenland used and in cooperation with UNESCO the recent conference in Ljubljana on the theme "Why invest in science in Southeastern Europe?" In addition they also prepared a number of other meetings, and made particular efforts to acquire and translate interesting professional literature so that a number of current issues, particularly popularisation of science, should reach not just the professional but also the general public.
a language very similar to the Romani spoken in Prekmurje. This meant that teaching aids developed in Burgenland could to a large extent also be suitable for Roma in Prekmurje.

How to achieve a better atmosphere for investment in science?

There are still many similar opportunities to exchange professional experiences. This is fully confirmed by the previously mentioned international meeting on the theme of investing in science in Southeastern Europe. Representatives of countries from the region who presented scientific research work, achievements, difficulties and plans had interesting opportunities for mutual comparison and, particularly in the light of what is achieved in the most developed environments, finding possibilities for achieving an atmosphere more conducive to investment in science in their own individual countries. In scientific and professional circles in all environments, it is self-evident that they know how important science and investment in science are. We therefore have to move beyond "preaching to the converted" to a discussion of how to attract decision-makers, i.e. politicians and the wider public. We must all understand the rules of today's globalised world and knowledge-based economic development, and must be aware of the importance of investing development aid and our own funds in knowledge and development.

Who gains and who loses?

As mentioned at the outset, sooner or later the countries of SE Europe will also be members of the EU. If they are weak in the areas of science and research, this would be bad for the other European countries, too. It would hinder common efforts to realise the Barcelona objectives, the Lisbon Strategy and various other development projects. Such weak links must be strengthened to make the whole chain strong ... In this sense we must modernise science "systems" in SE European countries, adjusting them to modern standards, through effective investment in human resources and infrastructure, effective acquisition of jobs and products with high added value, competitive goods and services so that – after they have made great efforts to join the large European family – they do not remain losers.

Over the last three years, the Austrian Ministry of Education, Science and Culture has supported such efforts and awareness-raising of the importance of science and research through tenders for joint research projects with researchers from Austria, Slovenia and the countries of SE Europe and Bulgaria.

Plans for Slovenia's presidency of the EU

The Austrian Scientific Institute – in cooperation with outside consultants – is already actively preparing for the period of Slovenia's presidency of the EU in the first half of 2008. This period will be particularly appropriate for selected topical discussions and preparation of plans and strategies, not just Slovenian and European, but also global strategies. Thus, for instance, Dr Polzer has worked with Slovenian and other partners in designing a draft EU programme for international scientific research on the theme of Global Research Initiatives for the Implementation of the UN Millennium Development Goals (www.globalgoals.eu)...This involves realisation of the objectives of the United Nations programme to reduce poverty and for more balanced development, to which international scientific cooperation can, as mentioned, make an important contribution.

From utopia to reality

Although it might seem somewhat utopian, it would be right at least to start more seriously discussing certain coordination on the global level. A specific proposal has been prepared to develop – similarly to the system in the European Research Area – global research fields and to coordinate international scientific cooperation. This on the one hand would be important for the rational use of resources, effective cooperation with important institutions such as UNESCO, the World Bank, international research organizations and research institutions such as JRC and others in the EU, for better use of infrastructure, the design of relevant fields and other reasons. On the other hand, such an approach would also be important to attempts in the global arena to achieve respect for modern research standards, relevant legislation and ethical recommendations in scientific and research work. In connection with this second issue, Dr Polzer has already contributed to the design of some starting points for discussion on ethical limits of research (Ethical Limits of Research – The European Voice(s) in the Global Quest for Consensus/Standards).
These are in any event broad, important themes, where it is important to achieve a consensus, since it is not enough for issues to be appropriately regulated in only certain areas; where there is disorder and a lack of transparency, there is great risk for contentious research, dirty business and an unacceptable image of science. Examples of such unacceptable behaviour, for instance in medicine and pharmacology, are not restricted to history – modern biotechnology and biomedicine are not immune to such dangers as reproduction cloning in human medicine, or other attempts, and so it is right to form global standards and to attempt to ensure global respect for them. For such global issues, cooperation with UNESCO would be particularly important and has to date also proven to be very suitable.
Dr Miroslav Polzer expects before the end of the year – and of course particularly in future plans – the parent organizations, that is, the Austrian Ministry of Education, Science and Culture, the Centre for Social Innovation and the Slovenian Ministry of Higher Education, Science and Technology, to continue to support their scientific and other activities of importance for development in Slovenia and in the wider European area.

Centre for Social Innovation Vienna (ZSI) – www.zsi.at

The Centre for Social Innovation (ZSI) – the parent institution of the Austrian Science and Research Liaison Office (ASO) Ljubljana – is a multifunctional social-scientific research institute which aims to reduce the gap between the needs and potentials of modern information and knowledge societies by systematically linking the knowledge generation with the application of knowledge.
Social innovation is directed towards the initiation, adoption, improvement and extended implementation of new forms of social interaction and social conduct, all of which affect development processes in public administration, political institutions, social partners, the business sector and civil society.
In its various capacities, the ZSI contributes to socio-economic goals in support of:

- the social, ecological and economical sustainable development of our society;
- European integration processes by enhancing scientific competencies and by implementing knowledge-based projects;
- the upgrading of scientific infrastructure as well as the efficiency and efficacy of social scientific research in the European Research Area (ERA).

The top priority of our projects is to develop applicable innovative solutions to socially important questions. Our projects are rooted in sound scientific principles and based on interdisciplinary and international cooperation.
Within the two competence areas "Work and Equal Opportunities" and "Technology and Knowledge", social innovation is both practically and scientifically supported by interdisciplinary and international cooperation.
Analysis and shaping of social innovation are dealt with in a multitude of projects covering a continuum of fundamental research, applied research and policy advice.

Examples of SEE related projects:

- IS2WEB – Extending Information Society Networks to the Western Balkan Region – (http://www.is2web.org) concentrates on focused training and mentoring of a limited number of promising research institutions which are identified in a first step through a thorough mapping of Western Balkan research organisations operating in the IST area. Complementary activities to facilitate networking will allow these organisations to exchange ideas and pursue joint research collaboration with their EU counterparts.
- SEE-SCIENCE.EU – Information Office of the Steering Platform on Research for the Western Balkan Countries (http://www.see-science.eu) is a support action for the Steering Platform on Research for the Western Balkan Countries. The Steering Platform was implemented under the Austrian EU Presidency in the spring of 2006 and will be continued by subsequent presidencies (Finland, Germany, Portugal, Slovenia). Its aim is (a) to structure S&T policy dialogue between the EC, the Member States, Associated States and third Western Balkan countries and (b) to monitor the progress of co-operation between the EU and the Western Balkans in the field of S&T and related foreign policies (e.g. development co-operation).
- SEE-ERA.NET – (http://www.see-era.net) is a networking project aimed at integrating EU Member States and Southeast European countries in the European Research Area by linking research activities within existing national, bilateral and regional RTD programmes.

R&D in Slovenia

Quark, Winter 2006/7

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Coming Together in Group Projects of All Sizes

By Boris Čerin

Interesting research projects attract groups of well-qualified specialists. In the EU, these forms of association take place at a very intensive level. Is Slovenia able to follow these trends? Professionalism and interoperability are currently very much to the fore in the science world. We need both, which means that the education system, in particular the universities, must also follow these trends, which can only enhance them still further. The requirements of business and industry are even further to the fore; however, other requirements relating to professionalism are also present – in healthcare, in research of social significance, in the humanities, and in environmental protection research. There is also the issue of the size of individual forms of research association. Where do they start? At the universities, during one's years of study. They then continue through established forms of association of all sizes, right up to things like the 6th EU Framework Project, which brought together 150 laboratories from almost all countries of the EU. And what about incentives, at all levels? Who should provide them? Good ideas are in demand, everywhere and at all levels. All these requirements, with all their diverse problems, are already regular items on Slovenia's agenda. The question is whether they are being tackled strongly enough, with sufficient quality. We discussed these and other topics with the Minister of Higher Education, Science and Technology, Dr Jure Zupan.

QUARK: You were a successful researcher for a number of years, weren't you?
ZUPAN: I worked in the field of quantum chemistry, ceramics, chemical informatics and statistics, neural networks and computing for chemistry. I worked in science for quite a number of years. In the course of my scientific research work, I was therefore able to recognise well-planned solutions, as well as those deficiencies and weaknesses that could be removed. So for some years I have had a fairly good idea of what requires improvement in scientific research.
QUARK: Have your reflections from your time as a scientist been useful to you as a minister?
ZUPAN: Many of the difficulties I saw before I became a minister have not diminished sufficiently, although one can detect a gradual change in conditions in certain areas. In science policy, there is still a considerable number of monopolies and "feuds". The "you scratch my back, I'll scratch yours" cycle has still not been broken.
My view of many of the problems then came into clearer focus. The correct evaluation of quality in both the scientific and professional areas should be mentioned here. Today I am stressing ever more that quality must be the sole criterion, whether from the scientific or professional standpoint.

QUARK: You were professor at the Faculty of Chemistry, as well as being a researcher at the Institute of Chemistry.
ZUPAN: They go together. A professor without research experience is an unsuccessful professor; a researcher who is unable to bring younger generations through is just dead wood. One component can be more present than another, but they must both be present.
QUARK: Are you able to use any of your experience from research and teaching work now?
ZUPAN: Of course, and I have also been able to use other experiences – experiences from cooperation with the business world. It is important to be familiar with administration and politics, although I do lack legal knowledge. There is quite a lot of complexity in my current work.

Higher education studies

QUARK: One important goal of your work is to bring science and higher education together. When you initiate recommendations, universities can choose to reject them, in the name of autonomy. Some are of the opinion that they enjoy a monopoly position.
ZUPAN: Staff selection is left entirely up to universities or individual faculties and departments, which is extremely bad. In Slovenia the term "university autonomy" is somewhat distorted. Quite a lot of nonsense is hidden behind the word "autonomy". I'm thinking in particular of elections to the highest positions, i.e. full professorships, which are planned in the same way as the selection of the lowest-category officials, with tenders that are only open for a week or two.
Furthermore, self-evaluation, an exceptionally important element of quality, is at a very low level in Slovenia. There is too much overvaluing of one's own abilities. If you speak to a researcher at an institute or a university professor, you will seldom detect any dissatisfaction with their own knowledge. I don't mean by this that researchers and teachers should undervalue themselves, just that I wish to draw attention to the need for the kind of self-criticism that drives an individual to improve their work and to build their professional career in a more thorough and thoughtful way.
The small number of universities here means that most people who lecture do so at the university at which they finished their studies. I hope that the increase in the number of universities in Slovenia will augment the flow between institutions.
QUARK: What is your assessment of the number of graduates as a proportion of the number of inhabitants of the country?
ZUPAN: If one looks at the percentage of students enrolling in university in an individual year, the level is satisfactory. The percentage of graduates is also quite high. It is merely the length of study, which in Slovenia is seven years on average, that is of greater concern. If one looks back seven years, to 1999, one sees that only 11,000 of the 28,000 or so that enrolled have actually graduated.
QUARK: How do you view the Bologna process – as an opportunity or as a change made without clear objectives?
ZUPAN: Of course they are an opportunity. They must be implemented in a high-quality manner. I am fully in favour of the Bologna process, but I would prefer to see programmes modified in a high-quality manner but slowly; the more quickly they are modified, the poorer they are. Unfortunately, what I've seen done so far in this regard is somewhat disappointing. Many things have indeed been done

Minister of Higher Education, Science and Technology, Dr Jure Zupan.

too quickly. On many occasions it has been merely a case of imitation, where several new programmes are made to arise from one old one instead of old programmes being amalgamated and reoriented by means of optional subjects. New programmes offer too little choice, too little transferability and too little that is new. The knowledge required to have been demonstrated upon completion of study has been outlined more or less acceptably; the knowledge required for enrolment in a course or for the commencement of study of an individual subject has been defined less well.

QUARK: Is it the introduction of new programmes that is the problem?

ZUPAN: No, the main, core subjects must be like that, must define education. We can distinguish three types of subject: core subjects, compulsory optional subjects and entirely optional subjects.

The core is represented by those subjects that are fundamental to a certain education, on the basis of which one acquires a professional title. Then there are the optional subjects, which introduce a certain specialisation or orient a programme in a certain direction. Engineers will be able to choose a certain stream, e.g. aviation, shipbuilding, mechatronics, and so on.

Optional subjects become compulsory as soon as one opts to follow a certain specialisation, since they define a narrower specialisation.

QUARK: In your programme you mention new universities in Slovenia. Some are of the opinion that this will fragment and weaken Slovenian academia, while others talk of a breaking of monopolies.

ZUPAN: Faculties are responsible for their own quality. Students will vote with their feet. If they are not happy in Slovenia, they will go to universities in Vienna, Munich or Milan. We cannot shut our eyes to this challenge. We have four universities now. I want them to be high-quality universities. Every university must evaluate itself.

QUARK: According to the Shanghai study, institutes such as MIT are among the top universities. Will you be allowing Slovenian institutes to take part in teaching work?

ZUPAN: We have already done this. In February this year Parliament adopted amendments to the law meaning that all institutes now have higher education as one of the activities specified in their statutes.

QUARK: Can we expect an increase in the competitiveness of Slovenian universities in terms of bringing them closer to areas with a larger population, thus bringing down the cost of studying?

ZUPAN: From next year, universities will begin to feel the fall in the birth rate that has occurred in Slovenia. In the coming years, the number of students will fall by around 1,500 a year. This means that universities will have to design programmes of greater quality and make sure that access is made easier, in terms of location as well.

Opinions on the quality of Slovenian science and higher education

QUARK: Some people talk of "Slovenian Luddites" who deliberately belittle Slovenian science and higher education. So-called "Slovene studies" should prove that Slovenian science and higher education are relatively good. Are these criticisms at least partly justified?

ZUPAN: We always seem to get extreme opinions. Some people believe that all science and all scientists should work only for industry. This is nonsense of course. We must distinguish the goals and purposes of the technical and social sciences from those of the humanities and those of the medical sciences. Scientific work in the field of mathematics is not always applicable; the same goes for research that relates to the environment or health. Of course, since research work costs quite a lot of money, taxpayers ask what all this research gives them. For this reason it is important that researchers know how to explain why taxpayers' money has been used – that they know how to justify their research. It is necessary to know that research is evaluated in a number of ways. One possibility is through a new product; another is a new or improved technology. It might also be a new measurement methodology which is important because it means something can be measured more accurately. It might be a new form of product. One measure of success in science can also be the doctoral and Master's students, and those with a research record who taken up important posts. All these things can be achievements that are important to the economy. Then there are textbooks, as well as papers, although some people do refer to "paper-writing" in a pejorative sense. Papers published in good periodicals, with a high-quality readership, are of course important landmarks in Slovenian science and are also evaluated as such. In terms of progress made in the last seven or eight years, we now have substantially more publication than before, although most publication takes place in periodicals with a comparatively low readership. So it is not right to say that we have too many publications; rather, that the publication of high-quality articles in recognised high-quality periodicals must be increased. One way of thinking from the past is still with us: that those who do top science can do it, while those that door "poorer" science should go into industry. This way of looking at things is completely wrong. The best innovations and technological discoveries come from the best laboratories. Our practice shows that the best scientists are mostly frequently connected with industry.

Members of the Laboratory of Biocybernetics at the Faculty of Electrical Engineering of the University of Ljubljana constitute a young, well recognised, interdisciplinary team of engineers, physicists, chemists and biologists who together with researchers and medical doctors from the Institute of Oncology in Ljubljana are developing electrochemotherapy – a novel local treatment in which a combined approach of chemotherapy with high-voltage electrical pulses, known as "electroporation", allows for effective local tumour control. Electroporation can also be used effectively in nonviral gene transfection in vitro and in vivo. This is now their next undertaking.
In addition to devoted work, they also find ways of having fun – an important ingredient in team building and successful research.

Elaboration of prototype printed circuit boards for the Cliniporator, the first European clinical device for the treatment of tumours by means of electrochemotherapy. The Cliniporator has been developed in collaboration with European partners at the Faculty of Electrical Engineering, University of Ljubljana, and in close collaboration with colleagues from the Institute of Oncology in Ljubljana.

Cooperation with business and industry

QUARK: In what way do you cooperate with the Ministry of the Economy?

ZUPAN: Last year we introduced a new way of dealing with tenders: our ministry funded research to the prototype stage, and the Ministry of the Economy funded it from the prototype stage on. Research and development work are both therefore aimed at supporting business and industry.

QUARK: Some experts, and the union too, have been warning for some years

Dr Alenka Maček Lebar and Barbara Mali from the University of Ljubljana, Faculty of Electrical Engineering, during the measurement of electric activity of the muscle. Surface measurement of a muscle's electrical activity (electromyography) is a non-invasive technique used in diagnosis of muscle diseases and in training and testing of athletes.

that one of the biggest problems – insufficient cooperation with business – is caused by a lack of incentives. At the universities, cooperation with business and industry is not one of the criteria for election but can nevertheless increase revenue through contracts and patents. Institutes have introduced transfer to industry as one of the criteria, although there are significant restrictions on incentives. Will the amalgamation of fields mean that you will introduce transfer to practice as one of the criteria for election throughout and, at the same time, enable incentives by means of financial reward through contracts and patents?

ZUPAN: We wish by all means to make research and higher education equal in financial and substantive terms. Everyone must have an equal opportunity to undertake education and research work. When one speaks of different types of promotion, e.g. scientific or teaching promotion, and scientific or teaching titles, different achievements are of course important. If one looks at professional titles, at professionalism, they must be professional achievements. And if one looks at habilitation, teaching abilities are of course more important. We will have to take this difference into account.

Teachers in higher education, as well as researchers, are insufficiently aware of their responsibilities towards the development of the profession as a whole. By the same token, business is still insufficiently aware that knowledge is a market asset – that knowledge is a competitive advantage and must be remunerated as such. If we wish to base our future on knowledge, we will have to buy it. Institutes cannot supply companies with knowledge for free; every entrepreneur must "build" a team that will propel him into the world of innovation, which is not cheap and certainly not free. In Slovenia, the cost of knowledge is still not a constituent part of the price of a product.

QUARK: A company director must already be convinced of the benefit of purchasing this knowledge for his company.

ZUPAN: If we're talking about decisions for new projects – or more specifically, in our field, new research – decisions must be taken at a certain level within a company that is oriented towards development as to which research is required and which not. It is

INTRODUCTION TO BALDER:

Balder is a typical "spin-off" company, established in 1997 when three scientists from the Jožef Stefan Institute and one entrepreneur with previous experience in running a company decided to transfer a certain technology and a corresponding product to the market. The product was an Auto Darkening Filter (ADF) based on an LCD (Liquid Crystal Display) optical shutter. This type of eye protection for welders allows clear viewing during the whole welding process and the use of both hands, while safety and productivity are considerably increased.

Basic research in LCD technology started in late 1990s in the applied research group within the Solid State Physics Department and through the years resulted in technology transfer and numerous developed products (LCD technology transfer to production – 1981, portable LCD oscilloscope – 1983, optical fibre testing device (OTDR) – 1988, optoceramic-based (PLZT) eye protection for pilots – 1989, magnetic resonance (MR) analyzer and imager – 1991, automatic welding filter, etc.) All of these products and technologies found their way to production, but due to limitations in the marketing and

MSc Bojan Marin, Director.

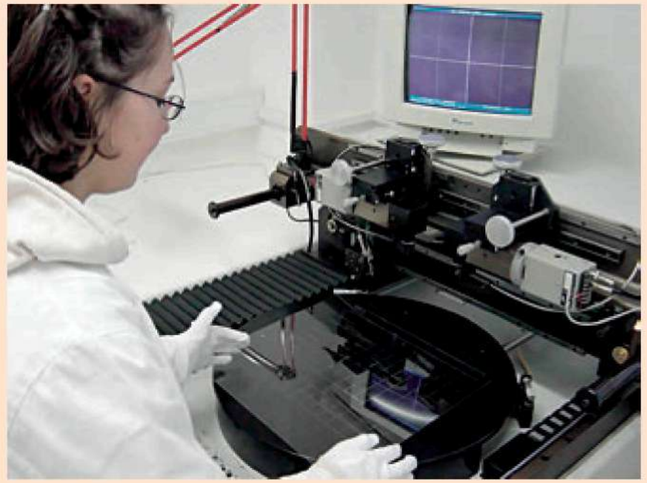
Miha Pesek

Thin film technologies.

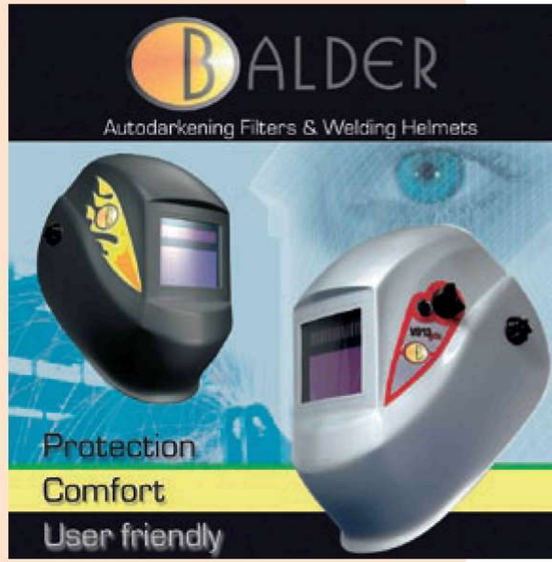
manufacturing abilities of the companies involved, the products never really achieved significant success. There was some interest in the early '90s for the ADF, but no one was willing to make the investment necessary to introduce the product to the market.

With its ongoing scientific cooperation with the Jožef Stefan Institute, Kent Liquid Crystal Institute (Kent, Ohio, USA) and other scientific institutions, Balder has one of the best R&D backgrounds among all its competitors. Among various national and internationally successful projects, Balder has actively participated in a joint research project with the Jožef Stefan Institute

Dr Janez Pirs, Head of the research team.



Glass cutting.



and Kent Liquid Crystal Institute, in which the participants received a NATO grant as part of the "Science for Peace Program". As a result of this project, a new, so-called ADC (Angular Dependence Compensation) technology has been developed. ADC technology considerably reduces the angular dependence characteristics of standard twist-nematic liquid crystal cells and therefore represents an important competitive advantage in the ADF market.

By now, Balder has become one of the world's leading auto-darkening welding filter manufacturer, especially known for the high quality and performance of its products. It is the only producer with CE, DIN and high-level DIN Plus certificates with the best possible optical ratings 1/1/1 (optical quality, light scattering, homogeneity) for the entire product line.

Balder is a company that exports more than 99% of its output. The main target markets are especially the European Union and the United States of America, while the company also sells to Norway, Japan, Australia, South Africa, Brazil, Argentina, Kuwait, Mexico, the Russian Federation, Belarus, Croatia, Serbia and Montenegro.

impossible to come up with 100% reliable answers in advance. Most likely, some good research will end up being selected and some bad research. They must take some risks: it is possible that some research projects, though they might promise much, actually yield poor results. It is also the case here that a successfully completed project might end up covering the costs incurred by a large number of unsuccessful research projects. An understanding on the part of company management of conscious risk in the research field is vital.

QUARK: What about the transfer of information from development, or from an individual research group working on a specific development task, to a potential user?

ZUPAN: This is a small part of the process. The better the link between the place where ideas arise and the place where these ideas are realised as products, the greater the possibility of success. If a company and its head of research, or those who make research-related decisions, is part of and connected with universities, institutes and doctoral studies, more ideas will be able to be tested within the company. They will find it easier to select successful projects on the basis of their own knowledge. If the company is set on one project only, they have nothing left if this project fails.

QUARK: Do you think that directors in Slovenia today are conversant with the development results coming out of our institutes and universities?

ZUPAN: My own experience tells me: not well enough. At the Institute of Chemistry, I visited most of the chemical plants in Slovenia as part of a process of collaboration with business. Far too many times we were asked: "So, tell us what doing?" This question says it all. Given the relatively small number of research groups in any individual field (e.g. chemistry or machine engineering), it is clear that people who ask that question are not familiar with the situation in their field in Slovenia, let alone the rest of the world. No one can afford to be so uninformed. Whenever a company has any problem whatsoever – technical, development, product-related – that they cannot solve themselves, the developers and engineers have to examine the world literature, where they can very quickly locate a laboratory or individual with the knowledge and ability to help them. These might be Americans, Japanese or Europeans. It is also possible to establish quickly who in Slovenia is working on the type of research in question and whether they have the knowledge to resolve the specific problems faced by the company. It only takes a few hours of sitting behind a computer, or a few days at most, and every company can find someone to talk to at a university or institute. There is therefore no reason for any company not to know its potential partners in Slovenia. The question from all of this is: Why is there not more cooperation? Is there no time? No interest on the part of researchers? A lack of trust? No money?

With regard to the introduction of new products into production, we can also look at the many years' experience of certain countries, particularly those whose own progress has been strongly predicated on knowledge. It is important that companies realise that those working for them must test many new ideas before arriving at the most appropriate solution. Behind every single successful project there are over a hundred ideas that were tested and that led, step by step, to success.

The ratio is 1:100. I would say that we have 500 ideas a year. If we test just one, the result will be precisely nothing if it is not successful. If we test 50, the likelihood that one of them will be successful is significantly increased. The risks are high; for this reason, we say that knowledge comes at a price. Of course, companies encounter such dilemmas. They accept the challenge or decide, right at the beginning and without a proper analysis, to withdraw because the risk is too great.

QUARK: The state also has mechanisms to lessen the financial risk, for example tax breaks.

ZUPAN: I should emphasise that we have already done a great deal with tax breaks this year. This year the finance ministry has introduced a 20 percent reduction in the tax base for every investment in research and development, whether in a company's own research groups or on the basis of research contracts with an institute or university. So, for every million tolars that a company allocates to research, the tax base is reduced by 200,000 tolars.

QUARK: That companies use the capacities of development groups within their own environment is probably the most desirable way of transferring the results of research work to the user of it. But this is not the only way. The whole process can also take place from developer to product, when the development team assesses that their research results can have a market application. There was an example of a company that arose from development work at the Jožef Stefan Institute.

ZUPAN: This is a good example of a company that was established after the successful completion of development work. The company grew from a development group and set up its business on fair terms. When the company was founded, the Jožef Stefan Institute gave 50,000 euros in start-up capital and became part-owner of the company to that amount, thus having an interest in its further development. When the company was successful on the market, it was able to pay back the money the Institute had invested, and the Institute was able to invest further. Perhaps others will also invest. All decisions regarding funds and ownership must be clearly visible. If the development work continues to be carried out at the Institute, the position, at least as far as finance is concerned, becomes considerably more blurred. No one knows precisely the share of state funds, who or how much is paid from the state budget and how much comes from the market. These are usually also the main reasons for various grudges, disputes and the like. An independent company operates transparently by settling all maintenance, research and production costs, itself providing funds for the purchase of equipment and for employees' salaries.

QUARK: There is a need for the re-investment of start-up and risk capital.

ZUPAN: Exactly. And as been demonstrated, they had a good idea at the Jožef Stefan Institute. They also had a science fund. All the larger institutes in Slovenia have one; the others can form one. Some part of the funds for each project can be invested in the fund and then used to fund promising or very risk-heavy projects. They must naturally have the proper controls and use the right method of tendering and allocating these funds. The rules for the operation of these funds must be very clearly laid out – who can use these funds and how, and what the rules are regarding

Cooperation between business and science

Left: The invitation from the Jožef Stefan Institute was accepted by a large number of business people.

Right: On his visits to companies, Prime Minister Janez Janša (second from right) is often accompanied by the Minister for Higher Education, Science and Technology, Dr Jure Zupan (first from right).

decision-making. The tenders for these funds, which are usually internal, must always be distributed to all interested parties in the company or institution. The worse thing that can happen is that they become closed circles open only to privileged users.

Technological platforms and EU development projects

QUARK: Does the EU finance development projects aimed at meeting needs demonstrated by technology platforms?
ZUPAN: Companies with related problems regarding certain technologies agree on the joint resolution of the problems they have in common – for example, toolmakers can be found in the car and plastics industries, as well as in many other branches of industry. This means that toolmaking-related problems can be brought together in a toolmakers' platform. All companies engaged in toolmaking, and there are quite a few in Slovenia, come together and discuss their problems. At the same time, they join with other companies of the same platform at the European level. The EU provides and funds these common platforms, of which there are just over 20 in Europe. They gather together companies that guide European research towards the resolution of problems. They will consequently propose themes for projects within the 7th Framework Programme of the new financial perspective. With this, Slovenian companies will enjoy the further benefit of joint appearance on the European stage, which in itself reduces costs. Their developers and researchers will be able to join the groups that will be formed to solve specific problems, thus acquiring knowledge and contacts, as well as further funding.
QUARK: What dynamics can already be seen in this area?
ZUPAN: Of course, European companies are coming together in this way, and Slovenia alone already has 10 platforms: for toolmakers, for the production of plastic products, for car parts, for carpenters and others. Some are more active than others. Activities first take place in one's own country, Slovenia in our case, followed by links with related platforms abroad.
QUARK: When we speak of ideas, of concepts for development tasks that should provide new products for manufacture or for the economy in the wider sense, it is said that these ideas most commonly come from young people when they are still studying, or at least they have an idea before they do their doctorate.

Minister of Higher Education, Science and Technology, Dr Jure Zupan.

ZUPAN: Ideas appear at all levels. Someone might have an idea when they are still at school.
QUARK: What about links with other faculties, not just natural science or technological but others as well?
ZUPAN: We now have a great opportunity to establish links with humanities disciplines, for example history, archaeology and linguistics, and the natural sciences. For example, archaeological research requires the use of analytical chemical methods to uncover the various links between sites and the origins of antiquities, determine the age of excavations, and so on. Of interest, for example, are various studies and discoveries of trade routes, according to which we are able to come to conclusions about how peoples interacted in the past. Today's linguistic research makes use of the latest computer methods from the information sciences. Statistics has become a basic tool for the social sciences because these disciplines always need to process large amounts of data. All the links between the so-called "hard sciences" (physics, mathematics, chemistry, biology) on the one hand and the social sciences and humanities on the other. They are a stimulus for both sides. We also know that the links between medicine and the natural sciences are extremely strong and that it is worth strengthening them still further, especially in Slovenia.
QUARK: What can your ministry, and also you personally, do to influence the intensity of these links?
ZUPAN: Through tender guidelines certainly. These guidelines allow us to give priority to groups that have forged links with others. The problem is, of course, the legislation and the rigid administration. Many things need to be set in motion in order to free up intellectual potential.
QUARK: What can be included in projects like these – perhaps doctorates, from economics say, so that someone might get a doctorate from their work in such projects?
ZUPAN: Doctorates can be the outcome of a project but not the subject of a project. A project is always planned with a target in mind – that is, an objective or result that one wishes to achieve. Research into the flow of capital, the flow of goods, etc. can make excellent economics research tasks. Those involved in them obtain results that they then report on and publish – if the research work is carried out at a sufficient level of quality of course. If a project has been well planned and set up, several candidates can receive a doctorate for it, depending on the quality of the responsible institution and the project. Naturally, there are restrictions as well. For a project funded by the state, only someone who has a past history of producing results may apply. Normally, this is demonstrated by papers, books, patents, areas of expertise and documented professional work.
There is a great deal of value in the purpose itself and in opting to bring together individual experts or individual teams within a logical unit, and for the pooling of knowledge and expertise in individual projects, because this is also important: that experts from various fields meet and look at the tenders, then work out a strategy for dividing the work up or decide to work jointly in a project.
QUARK: Does cooperation in larger international groups that will apply for tendered EU projects also open up new possibilities for research and development work?

ZUPAN: Slovenia has taken part in all EU framework projects from the fourth up to the current one, the seventh. We were extremely successful in the fourth and fifth. Around 13% of our proposals were accepted; in percentage terms, we were as successful as France.
QUARK: How often do these tenders appear?
ZUPAN: In the field of science and technology, these framework projects have lasted two to three years, with tenders every year. They have been divided into individual areas such as human resources, competitiveness, and so on. It is a condition that groups from at least two countries always apply.
QUARK: This is a continuation of the question on advantages of and possibilities for joint appearance at the local level. Is this already well underway at the European level?
ZUPAN: Yes, and as already mentioned, Slovenia was very successful in these projects; there is therefore no reason why our researchers should not be as successful at similar tenders issued by Slovenian industry – that is to say, if Slovenian industry were to issue similar tenders, they would also be successful. At the European level, it is mostly multidisciplinarity that succeeds. Every laboratory contributes its knowledge from its area of expertise; together, they are able to propose a good project.
QUARK: Was Slovenia not as successful in the 6th Framework Project?
ZUPAN: For the 6th Framework Project, the EU opted for very large projects that brought together up to 150 laboratories. Slovenian institutions and researchers were generally only associates in these projects. Our researchers simply could not call on the administrative support required to take responsibility for such large projects. These very widely based projects proved to be less flexible and there was too much administration. There were a series of complaints precisely about the size of the undertaking. The EU science commissioner, Dr Potočnik, promised that this would be addressed and corrected in the seventh framework project. Slovenian companies are still not participating to a sufficient extent. It is very much to be desired that institutions apply for tendered projects in concert with a company that will be the user of the project's results. The company would benefit directly from this, but must also contribute to project funding. It would gain knowledge and results considerably more cheaply than if it were to pay for them itself.
By involving companies in development and subsequent use, the European Union ensures that the projects are given the correct developmental guidelines, which are of considerable interest to companies and users.
QUARK: When can groups of Slovenian experts from institutes, universities and companies product forward an initiative for an EU development task?
ZUPAN: The most important thing for the assessors in Brussels is that the study is interesting to Europe. The first thing that is examined in every project is where it is targeted. At the EU level, unacceptable projects are those that are targeted only towards the solution of problems faced by a single company – this would constitute unlawful state aid (dumping). Companies must be capable of defining those problems whose solutions are beneficial for all companies in the branch in question. These are not projects directed towards final products but towards the resolution of common, wider problems whose resolution might enable companies to produce excellent products. In short, there are many stages to be passed through from the European project itself to the manufacturing of the product. Various tests and all sorts of experiments have to be carried out, and then there are issues relating to materials, the environment and so on. For example, at the Jožef Stefan Institute, they showed us a human puppet capable of displaying similar responses to certain stimuli as the human body. It would be of use to a number of companies – clothes manufacturers could test the thermal transmission of clothes or the durability of shoes. Other types of measurement testing could be performed on it. It is similar to European Union projects; the results of these projects must be widely applicable.

Basic research in Slovenia

QUARK: What proportion of research should be basic and what proportion applied?
ZUPAN: It is difficult to give an answer to this because one never knows when basic passes over into applied research. It is said, quite objectively, that there is almost no basic research at all in Slovenia. Unfortunately, there is quite a bit of research in Slovenia that does not end up being applied. Here we see one of the tasks of the ministry: tenders must contain more precisely defined research objectives and be presented in such a way that researchers will ask themselves what they can do in their own research that will be of benefit to the achievement of the set objective. We wish to introduce this important shift in thinking into everyday practice when tendering for projects.

Transfer of tasks to the Slovenian Research Agency

QUARK: Just over a year ago, some of the responsibilities and competences previously held by the ministry were transferred to the Slovenian Research Agency. Is the demarcation of these responsibilities and competences between the Agency and the ministry clear enough or are there still issues to be addressed?
ZUPAN: The competences are clear. The ministry works on research policy, the Agency gives technical, financial and logistical support. It holds tenders and organises evaluation procedures (the evaluators themselves are generally external). In short, the Agency only carries out what the ministry has adopted and wishes to do at the political level.

Inclusion of the Ministry of the Information Society

QUARK: One very important organisational change was the abolition of the Ministry of the Information Society. Some experts are warning that by doing so, Slovenia has not done itself any favours.
ZUPAN: The Ministry of the Information Society had a budget that was 3% of ours – a tiny amount. This area is now the remit of a special directorate within our ministry. The importance of this area has not been diminished by joining our ministry; we are giving special attention.
A number of important projects in this area lie before us, such as the establishment of the information superhighway throughout Slovenia, which is one of our priority tasks. We are planning the further construction of IT infrastructure, where I should mention broadband links and the digital radio network, including all the hardware as well as investments in the accompanying software; the complete digitisation of Slovenia's cultural heritage, the National and University Library, the national radio and television network, and biodiversity; the digitisation of all teaching aids, and so on. These are very big projects and very important ones for Slovenia. In short, I want to start tackling everything that comes under the umbrella of "the information society".

Is Slovenia One of Those Countries with Stronger Levels of Investment in Knowledge-Based Development?

By Boris Čerin

Progress based on investments in knowledge and in research and development is a strategic element of all government programmes both in developed and less-developed countries, where the efficiency of such investment is also an issue. Yes, efficiency. Where efficiency manages to secure this investment to an extent that makes it palpable, society looks favourably on large investment and on increases in subsequent investment in research and development, thus ensuring accelerated development at its very base.

Slovenia is not one of the leading countries in this area. It does lag behind somewhat, but not to an extent that would lead one to ask where to start. On the contrary, at the organisational level at least, we have already made use of a number of positive experiences from developed countries. An integrated approach, together with economic reforms, should guide Slovenia even more strongly towards knowledge-based development. One such organisational improvement, achieved in the last few years and based on the experiences of developed countries, has been the transfer of decision-making on the funding of research activities from the Ministry of Higher Education, Science and Technology to the Slovenian Research Agency. This project has now been completed, and the Agency has been running for almost two years. How this transfer took place and how the Agency is currently operating were some of the issues we discussed with its director, Dr Franci Demšar. We began by asking him a few questions about his own career.

Director, Dr Franci Demšar.

QUARK: You used to be a researcher at the Jožef Stefan Institute before turning to politics. What memories do you have of your research work?

DEMŠAR: I was a researcher at the Jožef Stefan Institute for 15 years, from 1982 to 1997. My field was magnetic resonance imaging. I spent two one-year periods at top laboratories in the United States, first at the University of Urbana Champaign, Illinois, and then at the University of San Francisco. I worked with Professor Lauterbur, winner of the Nobel Prize the year before last and inventor of magnetic resonance imaging, and Professor Brasch, who devised contrast media, without which magnetic resonance tests would be practically impossible.
This period of my life was a very happy and successful one. I published in the most prestigious periodicals and managed to accumulate quite a number of citations at the same time. I should also mention that I wrote the first Slovenian book on magnetic resonance imaging, which established the terminology in this field. Even now I receive invitations to join editorial boards and review research, from the best periodicals in the field. Unfortunately, I can no longer accept them, since my workload has become too extensive.

QUARK: Do you still retain links with researchers at Jožef Stefan?

DEMŠAR: As state secretary and after that, when I was defence minister, I had my own research group at the Institute; I worked for quite some further time on research tasks. This lasted until I became ambassador to Moscow, where I stayed for nearly four years.

QUARK: You also worked in Professor Blinc's department. He is regarded by some as one of the country's greatest researchers.

DEMŠAR: To my knowledge, Professor Blinc is the most cited Slovenian researcher, although a number of other Slovenian scientists have also achieved conspicuous success in recent years. I had an independent group within his department, which meant that I did not work directly with him on research tasks, although we were part of the same organisational sector. Professor Blinc did set the tone for research at the department – more precisely, he set very high standards which I believe are very important. These standards were world-class.

QUARK: In recent years we have seen a change of generations at the Institute. How do you see these changes?

DEMŠAR: A change of generations is important. Professor Blinc's work will be continued by Professor Muševič.
A change of generations is entirely normal in science. Younger people are, as a rule, livelier. They come with new, better ideas and a stronger spirit; this is particularly the case in the natural-technical sciences. I am wholly in favour of giving good, young specialists the chance to prove themselves. I am more inclined towards the American rather than the conservative European approach in this regard.

QUARK: Then you went to the Ministry of Science and Technology.

DEMŠAR: Yes, I became state secretary there in 1997. That was my first post outside the research field and was very similar to the work I currently do as director of the Slovenian Research Agency. I was faced with a number of important tasks, including the successful completion of the programme funding project through the stabilisation of science funding.

QUARK: You were also Minister of Defence..

DEMŠAR: The period after this, when I became Minister of Defence, was also an important one for me. I have pleasant memories of it. At that time we took decisive steps towards Slovenia's entry into NATO, which was the political decision of the day and one that also brought with it a requirement to organise things in a new way. A completely new set of regulations had to be produced; we have written and adopted

National Institute of Chemistry, Slovenia: Working on a new Field-Emission Scanning Electron Microscope (Karl Zeiss Supra 35 VP)

over 80 in that period. At the Ministry of Defence I gave special attention to information technology, so we were able to set our information system up in such a way that it stood comparison with the information systems of the other NATO member states. I also set up a strategic council made up of the-then Minister of Science, Higher Education and Technology Dr Jure Zupan, the subsequent Minister of Defence Dr Anton Grizold and a number of top scientists. Among other things we produced a plan for linking science and defence, which resulted in the first target research projects during Minister Grizold's term of office. Substantially increased funds have been earmarked for this purpose this year.

QUARK: You then moved onto diplomacy.

DEMŠAR: Yes, I went to Moscow for four years, where I was ambassador to Russia, the Central Asian states, Kazakhstan, Uzbekistan, Turkmenistan, Tajikistan, Kyrgyzstan and Belarus – a huge region and one that is important from a number of aspects, the economic being for me the most significant. When I arrived in Moscow, trade between Russia and Slovenia stood at 500 million dollars; by the time I left, this had risen to one billion dollars. Because government is such a crucial factor in the Russian economy, the work of the ambassador was very important, with many very specific matters being entirely dependent on the ambassador's ingenuity or knowledge. The work I did there was therefore very satisfying. We established very fruitful political links between Slovenia and Russia. A great many visits took place, including at the very highest political level. There were meetings between the presidents of both countries and a large number of ministerial meetings.

QUARK: These experiences are probably of benefit to you in your current post.

DEMŠAR: Not directly, but they have contributed to a wider understanding on my part of certain factors which are very important in posts like mine. This breadth of understanding can often help in one's assessment or when deciding whether or not to take a certain step. It can also help one to achieve the objectives set when carrying out a certain project.

QUARK: You are now director of the Slovenian Research Agency. You've been called the "Greenspan" of Slovenian science. Is there anything in that?

DEMŠAR: Maybe. It's a bit of a joke, but there's also a bit of truth in there. I mentioned Greenspan at a New Year's reception, as an exemplar of financial operation. The excellent organisation under his management is certainly an example to a great many people, not just us. When we had our New Year's reception for the Agency's expert bodies in 2004, I tried to outline what we would be doing in the future; I really don't like doing this in public because such announcements too often end up being merely a wishlist. But I gathered them together anyway and tried, in the most straightforward way possible, to outline how a good research agency should operate. I compared it with a national bank and said that the Agency would work well when it had a similar approach to the things it did, similarly establishing a series of mechanisms for calculating the outcome of every tolar spent, producing thorough studies and providing the basis for the right direction to be taken. A huge amount of work was still left to do if these goals were to be achieved. These requirements have been a challenge to me, which is why I chose to work in the state sector. At that time, 1997, I frequently spoke of transparency, when transparency was not in the foreground as much as it is today.

QUARK: Most of the duties and tasks that were previously under the remit of the Ministry of Higher Education, Science and Technology have been transferred to the Agency, along with quite a large number of ministry employees. Were the organisational changes difficult to implement?

DEMŠAR: Of course, at the start of the Agency's operations it was very difficult. The government had founded the Agency on the most cost-effective basis possible – the work now being done by 50 employees had previously been done by 70. We had to set up an accounting system from scratch. We had to ensure that all financial transactions were handled as they arose, subject to all possible controls, at the same time as setting up a new organisational system and ensuring decision-making capacity. This meant there was an immense amount of work to do from the outset. We had to adopt 18 new rules and regulations, as well as introduce a large number of substantive amendments, several of them of crucial importance.

QUARK: What were the key points of departure for the founding of the Slovenian Research Agency?

DEMŠAR: Coming up with the Agency concept was not a very demanding task in itself; such organisations are common in most developed countries. The Agency had to assert its autonomy and acquire the trust of researchers, who had to know that their research would be funded on the basis of quality and not of whoever was in power at the time; this was also one of the motives for establishing the Agency in the first place.

QUARK: Did you model your organisation on any country in particular?

DEMŠAR: In terms of organisation, we are closest to the Finnish system. That said, institutions such as ours are pretty much organised in the same way everywhere, so the features of our Agency do not differ greatly from those in other countries. Our system is similar to the Finnish in terms of organisational concept, being planned as two agencies, technological and scientific, although our technological agency has been set up but is not actually in operation yet. It has not yet begun to compile and publish tenders.

QUARK: The Agency has now been in operation foralmost two years. What tasks have proved to be difficult?

DEMŠAR: The need to take all procedures into account greatly hindered the implementation of decisions. There are expert bodies and then there is the administrative board. If a regulation needs to be amended, the further approval of the ministry and the government is required before it can be published. Of course, this exacting procedure does ensure that our work is subject to an excellent set of controls. We can't take shortcuts, although this would make our work easier. This is something I didn't think would be as arduous as it is. Nevertheless, we have still managed to adopt all the regulations with sufficient speed. Now, after the first year, we can say that we were sufficiently well prepared. We are now only introducing minor amendments. I want to complete these as soon as possible and thus ensure that funds for research are allocated in a fair way.

QUARK: Had the people who joined the Agency done this type of work before?

DEMŠAR: Of course, if we're just talking about the work itself. However, a transparent system needed to be set up here. One of the central tasks is the amendment of two regulations on the expert bodies that assess research proposals, and the rules on indicators and criteria.

QUARK: What are currently the Agency's most important responsibilities and competences?

DEMŠAR: At the basic level, we can distinguish three types of responsibility. The first involves work connected with the evaluation of scientific projects and programmes financed by the Agency. The second is the production of studies of scientific activities, which form the basis for strategic decisions. The third is the promotion of scientific research activities. Most of the work is centred on the first of these – the funding of scientific research activities and the implementation of tenders. These are first of all the ten most important ongoing tenders that concern the funding of research projects, followed by the evaluation of programmes that have been introduced for the first time, the selection of junior researchers and their mentors, and funding for research equipment. Finally, there are several further smaller funding items in the fields of journalism, the funding of scientific periodicals, monographs and conferences, the acquisition of scientific literature in foreign languages in central information centres, and another raft of funding for international bilateral scientific cooperation with more than 30 countries, which again entails a large number of tenders.

The preparation of all these tenders, the evaluation of applications and then the funding process take up most of our time. This is naturally very demanding work. Only a quarter of applications for research projects are funded. This percentage might be somewhat higher elsewhere. For example, we funded 250 applications from mentors of junior researchers out of a total of 900.

QUARK: The formation of the Scientific Council is laid down by law. What are its responsibilities and how can its impartiality be ensured?

DEMŠAR: The Agency has three main bodies. The Administrative Board, which adopts all decisions, is a formal body. Every document, every piece of funding is formally adopted at Administrative Board sessions. The second body is the Scientific Council, which has two very important functions. The first is to cooperate actively in the preparation of tenders, the tender methodology and the methodology used in the evaluation procedure. This year all methodologies will be published at the same time as the tender and will contain all details on the evaluation procedure; this is a change from previous years, when the evaluation methodologies were completely undefined. This is the main task of the Scientific Council.

The second very important task of the Scientific Council is the appointment of specialist evaluation bodies and assessors. This is a very significant change from the previous system, where it was the minister who appointed them. Exclusive responsibility for the appointment of these committees and assessors has now passed to the Scientific Council – that is, to the scientists themselves. This has reduced, or rather removed, the subjective decision-making which

COMMENDATIONS FOR YOUNG RESEARCHERS WHO COMPLETED MASTER'S OR DOCTOR'S DEGREES IN 2005 AT IJS

The education of young science professionals is one of the main tasks of our institute. In 1985 the Ministry of Science initiated the "Young Researchers" project, and within this programme a total of 823 young researchers have completed training at IJS. Under the guidance of mentors in research groups, these young researchers have completed doctoral and master's work and postgraduate specialised training in various fields of natural sciences, mathematics, technical and biotechnology research. Of these researchers, 355 gained doctorates, 387 gained master's degrees and 81 completed postgraduate specialised training. At this, the 17th conferral, commendations of the Institute were received by 19 doctors and one master's graduate. Alongside the young researchers, in 2005 another two researchers completed their doctorates and one completed a master's degree at IJS, and although they were not involved in the "Young Researchers" project, they will also receive commendations.

The Institute has facilitated for young researchers the use of appropriate apparatus and equipment, as well as the mentorship of experienced researchers. Moreover the Institute's links with numerous research centres and institutes in Slovenia and around the world have made it possible for young researchers to enhance their professional training abroad. In this way IJS, although not formally involved in the higher education system, confirms the fact that it can make a major contribution to the education of professionals in the scientific and technical fields.

researchers in the past, justifiably or no, complained about.

QUARK: Who appoints the Scientific Council? Is the appointment process laid down in law?

DEMŠAR: The Scientific Council is appointed by the Minister of Higher Education, Science and Technology, at the recommendation of the Government Council for Science and Technology. This is where the political involvement stops. The basic condition for the appointment of an individual to the Scientific Council is scientific excellence.

QUARK: Who are the members of the Scientific Council?

DEMŠAR: The president of the six-member Scientific Council is Professor Dovč, a biotechnologist. The other members are Professor Petkovšek (natural sciences), Professor Gadžijev (medicine), Professor Derganc (humanities); Professor Adam (social sciences), and Professor Turk (engineering).

QUARK: Some researchers and professors are asking where the union, the employees' representative, is. Has the Agency stopped working with the union?

DEMŠAR: I believe we are working together well. We have invited union representatives to take part in key meetings, in the discussion of the rules on indicators and criteria for evaluating scientific achievement, and in the discussion on professional bodies. I want good cooperation with the union. The union representatives know that our door is always open to them.

QUARK: The Government Council for Science and Technology also has a number of responsibilities. Where is their presence felt in the Agency?

DEMŠAR: The Council for Science and Technology is a strategic government council. Its main task has been to draw up the proposed National Research and Development Programme To 2010, which was adopted just before the New Year. It is an important programme. In the future its main task will be to monitor the implementation of this programme. The National Research and Development Programme has been formulated in a very operational way. In the strategic sense, the Council is a very important body.

QUARK: It is of prime importance that the work you do at the Agency is of high quality, given the fact that the Agency receives budget funding. Comparability with other EU states is of interest here, particularly in terms of percentage of GDP.

DEMŠAR: If we're talking about percentage comparisons, graphs and tables do a better job of presenting the information clearly. The graph I have here demonstrates that Slovenia is not exactly in the most enviable position when it comes to government investments in research and development, or in knowledge generally, and that radical moves are required if we wish to move forward. It is quite clear that valuable natural resources are not among the advantages enjoyed by Slovenia; all we have is knowledge. In the future this will be of the utmost importance. If we don't devote sufficient attention to knowledge, we will continue to shuffle along in the bottom third of European countries. We should follow the example of Sweden, which a generation ago radically increased its investments in knowledge, and join the other European countries that did so, such as Finland 15 years ago and then all the other Western European countries. If we look at the graph showing a comparison of investments in terms of percentage of GDP by individual European country, we can see that

Research programs supported by the Slovenian Research Agency

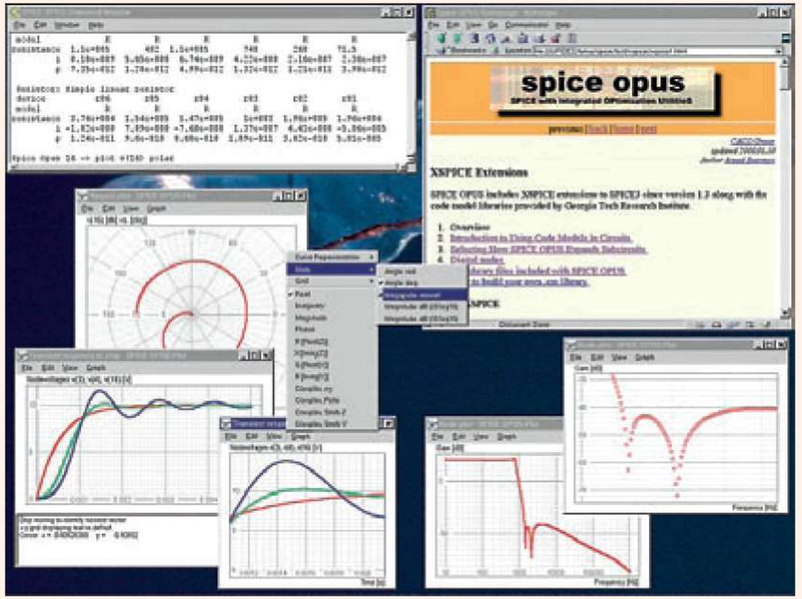
University of Ljubljana
Faculty of Electrical Engineering

The research program Algorithms and optimization methods in telecommunications is one of two programs which were among the best research programs selected by the Slovenian Research Agency in both 2004 and 2005.

The following research activities fall within the scope of the research program: retrieval, processing, characterization, analysis and modeling of real and synthetic telecommunication traffic; switching and routing optimization for next-generation networks; analysis and study of the impact of various network parameters on the quality of services (QoS); development of broadband networks, equipment, services and content; analysis of the theoretical limits of modulation methods and optimization of antennae in wireless local area networks; optimization of optical fiber measuring methods and development of extremely fast electronics; development of analog circuit optimization computer software for massive parallel computing; multimedia signal processing with emphasis on image and video processing, coding, visual object segmentation, tracking and recognition; and the application of algorithms developed for signal processing in communications to other areas of research (digital filtering in magnetic resonance imaging, formation of an acoustic space image ...).

The microwave weed destroyer is an example of using knowledge derived from telecommunications in other fields to improve the quality of life. It makes it possible to kill weeds without the use of harmful chemicals. It was developed in cooperation with the University of Padua.

The research program helps in creating and maintaining a group of highly motivated experts which is able to follow developments in the extremely rapidly growing field of telecommunications and transfer knowledge to the wider Slovenian society: indirectly through the development of new study programs and directly through R&D projects with Slovenian industry. Only in this way can the Slovenian telecommunications industry and service providers compete in the increasingly demanding world telecommunications market. The members of the program group are also actively involved in the development of the Slovene Information Infrastructure – SII as a part of the Global Information Infrastructure – GII.



Spice Opus is a circuit simulator with optimization utilities. It is a recompilation of the original Berkeley source code for Windows 95/98/NT and Linux operating systems. Georgia Tech Research Institute's XSpice mixed-mode simulator was added to the Berkeley code. It was developed for the internal needs of the program group in researching optimization algorithms and is now used in universities in more than 40 countries.

Optimization and development of new efficient algorithms for signal processing, data transfer and routing is one of the most important telecommunication research fields, as it enables more and more efficient utilization of limited resources and limited spectral bandwidth. On the other hand, algorithms developed for telecommunications can be successfully applied in other areas of human activity to improve the quality of life (medicine, aids for disabled people...).

The "archery-target" antenna is a directional antenna evolved from the short-backfire antenna (SBFA). The new antenna has an additional annular reflector and a much-increased large reflector when compared to the SBFA. The new antenna is simple to manufacture, since the supporting structure for the small and annular reflectors can simultaneously serve as a radome.

The JPEG decoder is an example of using a reconfigurable system for prototype implementation of image processing algorithms developed by the program group, which enables simultaneous HW and SW development. The system is supported by all necessary SW tools for algorithm analysis.

Slovenia's position is not good enough – but also that Europe as a whole does not invest as much asthe US or Japan. Not forgetting China of course, which in all respects is catching up with and overtaking its competitors. This sector of government investment will most likely be the key factor in Slovenia's and Europe's success in the future. Of course, these government investments must go hand in hand with investments in the economy. This means that Slovenia will also have to change its tax policy, which will only be possible through tax reform. I have the feeling here that Slovenia is on the right track. Europe as a whole is also working in this direction.

QUARK: Around the world, such organisations as yours tend to be independent in particular from the government of the day, which is understandable since research projects are multi-annual and it takes time to set up a high-quality research group. Nevertheless, government intervention would be welcomed if the work of your Agency was not up to scratch, wouldn't it?

DEMŠAR: In countries with a serious tradition of democracy, such agencies are way ahead of us in terms of independence. In Finland for example, there is only one government representative on the administrative board of their Academy of Science. This means that decision-making is completely independent of the government. It is the same in other European countries,

to a slightly lesser extent. In Slovenia, the government has a majority on the administrative board. However, as regards our Agency at the current moment, the most important thing is that we have established it. Our level of independence is entirely appropriate to the Agency's level of development. So alongside our own efforts to build a wide basis of trust, there is the possibility of the government intervening in Agency operations should our work prove to be unsatisfactory. What I personally wish for is that we prove, through the quality of our work, that a research agency is the correct framework. I have certainly done everything in my power to ensure that the Agency gains the trust of both the political and research spheres and that it builds its independence through the foundation of high-quality work, which is in turn the basis for greater independence.

QUARK: Some tradition of high-quality work will still be required.

DEMŠAR: Of course, over time our own efforts and the maturing of society as a whole have to assert themselves. Everything is linked to that.

QUARK: Which of your tasks do you see as a process over which constant vigilance must be exercised?

DEMŠAR: This year we are devoting considerably more attention to studies that then form the basis for funding. In both personnel and organisational terms, we have reached the level required for the high-quality performance of tasks. Constant attention must be paid to the issue of funding of course.

QUARK: Yes, the evaluation of proposals and results of individual research projects and programmes are among the most important responsibilities and competences of your Agency. The remarks made on evaluation up to now have been that division should not be used in the evaluation formula since the marks thus obtained are too unstable. Moreover, three methods of evaluation need to be introduced: natural-scientific, social-scientific and technical.

DEMŠAR: The evaluation of research projects, programmes and mentors is a very important task. It must be a process that satisfies quality criteria, and rewards good, high-quality, internationally comparable projects. Second, the evaluation of projects must include the issue of "relevance"; that is, that it also takes account of the economic or social importance of the topic in question. Furthermore, we must take into account the importance of cooperation with other users, for example business and the EU. In short, a sufficiently broad basis must be provided for the evaluation process. The right relationship between individual parameters, between quantitative results and the evaluations made by qualified assessors, must also be established. The evaluation procedures that we will have in place this year have already been planned this way. Quantitative evaluations are made on the basis of papers according to COBISS, citations, quantitative elements of relevance, how much money an individual researcher receives from other sources in a certain period not from the Agency – that is, from other ministries, from business, from the EU. All these are quantitative elements. Our methodology for acquiring this data is good enough. Then there are the assessments provided by assessors.

Director, Dr Franci Demšar.

One very important thing we are introducing with the new rules is the evaluation of the most important achievements. When applying, a researcher presents, in the form of a report, their two, three or four most important scientific achievements, and then separately the most important achievements of relevance. That is to say, we only look at how high someone has "jumped". How high they have managed to climb. Not quantity but quality. This is a very important step towards improving the evaluation procedure. It is comparable at the European level and has been drawn up using the English model. Prior to its introduction, we consulted people responsible for financing English science.

So now we take account of someone's most important achievements, as well as the importance and description of the project. Foreign assessors must be present – that is practically the rule in Europe, and Finland strictly adheres to it. Great Britain is an interesting case here, given its size – it mainly uses foreign assessors because researchers there are usually too well known to each other, even in a country of that size, for domestic assessors to be entrusted with the task of assessing scientific results. So we will continue this practice, which we started last year.

In parallel with the high-quality evaluation of excellence, we also have evaluation of relevance. Domestic specialists are required for this task. Here we will involve business and industry more strongly, with every application for funding of research being evaluated on the basis of six marks: three quantitative marks and three awarded by different domestic and foreign assessors.

The weight given to individual elements will depend on the scientific discipline in question. For the humanities let's say, funds from other users are not an important indicator because they involve topics of national significance which the state must finance itself, independently of whether or not they are financed by someone else. In technical fields, we do not finance those projects that are financed by business; in the field of the natural sciences, we do not finance those financed by the EU or the US. We will respond to all these issues by introducing all these procedures this year.

QUARK: One criticism of the previous evaluation regime was that certain coordinators were "familiar" and partial. The general opinion of the new system is that the quality of evaluation has fallen considerably. Some are even talking of a degrading attitude towards our experts; because of a few rotten apples, they are not being trusted to be professional and honest.

DEMŠAR: Those that are not successful in acquiring funding for their project, and three quarters do not (which is a failure rate common in other countries), will naturally criticise us. In the past, some of the criticisms levelled at the evaluation process were justified; this year we hope that the evaluation system we have introduced will gain the trust of science. We will no longer have, this year or in the future, coordinators who are able to allocate funding on the basis of existing "feuds". Many people are unhappy with this because they are no longer connected to the centre of power. We do not want centres of power any more, we want centres of quality.

QUARK: What is your assessment of the study by Slovenian researchers that showed that science and higher education in Slovenia were world class? Shouldn't this be the type of activity supported by the Agency?

DEMŠAR: I believe that this is an important study and we have asked for the results. We will also be interested in further developments with this study; and, of course, the results as they appear (I trust the methodology is correct), are encouraging in this regard.

QUARK: How do you read the attitude of Janez Janša's government to research and development, particularly to the Agency, and that of the Slovenian parliament as a whole?

DEMŠAR: As I have already said, the Slovenian government is placing very great emphasis on the importance on tax reform and, consequently, on the establishment of conditions that will allow the revival of the National Research and Development Programme. A doubling of investment in research and development is envisaged with the reform using the formula of one per cent from the government and two per cent from business and industry. Tax reform and its practical implementation are very important to us.

We are working with the government through two ministries. Cooperation with the Ministry of Higher Education, Science and Technology is obviously the correct way to proceed. Viewed as a whole, this cooperation is good. The ministry is responsible for coming up with a strategy, and it plans every tender by laying down concrete guidelines, project priorities, priorities in the appointment of mentors for junior researchers, relations between scientific disciplines and everything that goes towards defining the strategic objectives; our task, within the framework of these priorities, to carry out the tender in a professional manner. We also work with the Ministry of Defence, with whom we have also successfully coordinated our activities.

QUARK: Agency operations frequently imitate the organisation and work of the most developed countries. However, these countries are also constantly on the lookout for better solutions. It can happen that some projects require substantial modification over time owing to the fact that they do not work as well in practice or they need to be replaced by new projects. A certain flexibility will need to be demonstrated. Have you set up your work so that you are able to respond sufficiently flexibly to changes?

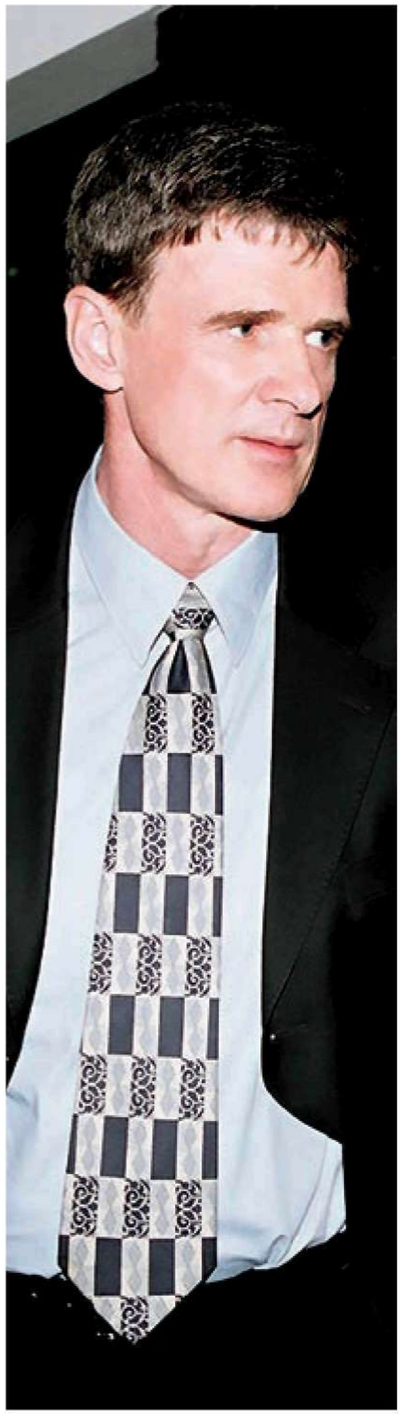
DEMŠAR: Our flexibility should be clear from my previous answers. The adoption of 18 regulations in a year already says something about our ability to do this. We will enhance still further the overall transparency of our work, including more easily accessible data and information on our website, where records of tenders containing all dates, forms and rules will be available for inspection from this year. The "white paper", a report on funding, which was previously drawn up for a year in advance, will be published as we go along. Everyone will be able to view their project on the internet and see how much money their organisation has received for the project and how much is planned (how work is progressing). The ability to see where the funding has gone will be greatly increased because in many places conflicts arise between project heads and research organisations. We will give information direct from source to hundreds of users. At the same time, all these efforts must take into account the requirement to ensure that the basic aspects of funding are stable.

QUARK: You also evaluate the operations of the Agency yourself. Your findings have led you to advocate stronger involvement.

DEMŠAR: I regard this year as a very important one. If last year was devoted to construction and the laying of foundations, this year is devoted to the fine points of methodology. There will be four documents for every tender. In addition to the text, the tender and the rules, which will be supplemented with a number of amendments, a precise evaluation methodology will be provided. The Scientific Council will work on this methodology and adapt it to individual scientific disciplines, individual fields and the specifics and guidelines of the ministry, which will be linked to the national development programme.

At the end of the year a collection of all documents in a 50 x 7 register will be made available for continual monitoring, containing all documents, publicly accessible prior to the publication of tenders, and open for comments by researchers and press, because it is most important for us that we improve the system and make it a fair one, even though it might be somewhat rigid.

Secondary-school pupils and their guide, young scientist Luka Snoj, at the Fusion EXPO at NTC at the Reactor Center in Podgorica.



By Jasna Kontler Salamon
DELO

Dr Jadran Lenarčič, director of the Jožef Stefan Institute

"There has never been the kind of mood here that you can sense now"

Dr Jadran Lenarčič, director of the Jožef Stefan Institute.

My first meeting with the director of our biggest research institute – I do not know exactly when it was, but it must have been quite a few years ago – was anything but typical for getting an idea of the profile of this kind of manager. I was viewing an exhibition of his paintings at the institute's exhibition hall. Aside from the fact that Dr Jadran Lenarčič has for decades now been one of Slovenia's top researchers in the field of robotics, he is also a gifted painter. He admitted, however, that ever since he took on the leadership of such a large enterprise, he has lacked time for this and other kinds of hobbies, since in addition to his duties as director, he also works as a researcher and university teacher.

Is it true that at first you really did want to study painting?

It is true, but as a pupil at the Koper grammar school I was also thinking about studying mathematics, which seemed to me very close to philosophy, which I loved. For me life is eternal doubt, and I think that every sincere person is a doubter. I always had doubts about everything I did, so I also had doubts about my choice of studies. It was only at the last moment that I decided to study electrical engineering.

In any event, this is quite an unusual combination of interests. What subjects did you shine in most at secondary school?

Since I always had decidedly broad interests, I also did well in many areas. I could have studied languages or anything else. At that age – I had always been in love with everything to do with the sea – I was also very drawn to the idea of devoting myself to yacht design. Maybe I really should have enrolled at the art academy and become a designer, since I am still obsessed with designing – I am always designing something ...

How did such an artistic soul finally accept studying engineering? Did anyone, your parents perhaps, force you?

No, no. The way it happened was that when I came to Ljubljana to enrol – I had already decided on mathematics then – I first dropped in on my brother, who had graduated in electrotechnology, and he said to me: What do you want to go to classes over the road for, just enrol here! So I enrolled, but then I was very unhappy the entire time of my course, because I decided that this was not for me. Nevertheless I was the first to graduate in my generation.

Then you went on to get a master's and doctor's degree in electrotechnology, and of course you are also teaching it. So in time did you change your attitude to it?

Actually everything changed for me when I started dealing with automation and robotics in my senior years. I really found myself here, since this discipline also has a lot of mathematics and philosophy, and a sense of design comes in very handy in the field of kinematics. In any event I was determined from the start that I would work in science.

And going abroad did not attract you, since in the kind of research field you are pursuing you could have easily found work?

I never thought about moving abroad, although I worked a great deal abroad, lecturing at a number of universities, more recently particularly in Italy – perhaps also because I am drawn there by my Mediterranean soul.

So what drives you or guides you in your new and most responsible position to date? What vision did you bring with you to the position of director of the institute?

I am of course firmly convinced that the institute needs to be more involved in the environment to which it belongs, both in the Slovenian and European research arena, in the economy and in other activities – and especially in the development of medicine – and of course in higher education. I think the time has finally come for a change to the established practice whereby institutes were separated from educational work, and when researchers could only work privately at universities – I myself, for example, have always had extremely good relations with the Faculty of Electrical Engineering, where I collaborate on the subject headed by Prof Dr Tadej Bajd, but this does not change the fact that along with my institute colleagues I could not do this in connection with the institute. At IJS we have partly resolved this problem by co-founding The Jožef Stefan Postgraduate School and the Polytechnic of Nova Gorica (now University of Nova Gorica), which are in fact both independent legal entities, and now we are drawing up a contract with the University of Ljubljana that will serve to define our cooperation in the work of its faculties, and in this way to our mutual benefit we will be able to perform a role together in undergraduate and postgraduate courses. I am convinced that good researchers must also teach, while at the same time all students and professors should have the chance to do research.

Are you in this way continuing the work of your predecessor Prof Dr Vito Turk?

In my own way most certainly, except that in the past the institute failed to arrange completely its relationship with the University of Ljubljana, with which we no longer wish to have any conflicts, while now, I hope we will finally be able to do so. I know that our associates and friends at the university sometimes feel impinged upon because IJS has established two schools, one of which is already offering undergraduate courses, while the other is planning this as part of the Bologna reforms. But I believe that there is no reason for fear of duplicating courses, since our courses complement each other and in this way offer both of us great opportunities for better cooperation.

COOPERATION AGREEMENT BETWEEN THE JOŽEF STEFAN INSTITUTE AND JOANNEUM RESEARCH

On 15 March 2006 the Jožef Stefan Institute and Joanneum Research signed a cooperation agreement on exchanging information and experience in research and practice in a number of areas. Joanneum Research is one of Austria's largest non-academic research institutions, the primary role of which is to conduct applied research and development activities on behalf of private business and the public sector. The organisation, with a staff of over 380 highly qualified researchers in 14 institutes, is 90% owned by the province of Styria and

10% owned by the Dutch research organisation TNO.

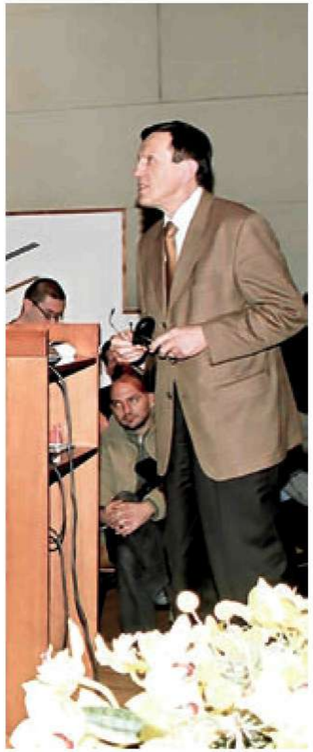
On the basis of this agreement the Jožef Stefan Institute and Joanneum Research have already organised two workshops focused on the presentation of research activities in the fields of the environment, energy research, biomedical technology, and production and communications technologies. New contacts and initiatives in joint research programmes have already begun as a result of the meetings held thus far, and preparations for a workshop on nanotechnology in autumn are underway.

Recently there has been more frequent talk of IJS being too big, or of how it would be good to divide it up into several institutes, attaching one or two of them to the university. What do you think about such ideas?

I think that this cannot happen, since IJS, along with its size and diversity of research, is too good a brand for any intelligent person to want to relinquish. I think that the institute is imprinted in the genes of every Slovenian, we are known and valued throughout the world, and the changes that we plan to carry out in our further development will certainly not divide the institute up into little parts, but will if anything consolidate it.

What changes are you thinking of?

There are of course many things at the institute that can be rationalised. I am thinking primarily of linking up our research fields, in order to make better use of the enormous knowledge that together we possess, which if it remains confined to narrow scientific fields, is not as effective as it could be.



There are many problems that can be tackled together by researchers of very different profiles, and all of them – technologists, electronics specialists, computer scientists, physicists, chemists, biochemists and so on – can also collaborate on joint programmes, such as those for the commercial sector, the Slovenian armed forces or medicine. This kind of cooperation does already exist at the institute, but we are working to establish more and for this to become the new force at the institute.

But is there sufficient will among the researchers for this?

There is, and I think that there has never been the kind of mood here that you can sense now. What is happening now, these positive tensions, the firm determination to refresh and rejuvenate the institute, well at least I in all my institute years – and there have been a few – have not noticed it.

How do you account for such a positive change and such enthusiasm?

On the one hand it is a reflection of our development, which has brought us to the current level from which in turn we see new developmental possibilities. But without doubt our increased momentum has been helped by the environment we are in, since it seems that science is gradually and finally acquiring a more visible role in the consciousness of Slovenians and in the consciousness of those who conduct our policies. I think that we are all sick of the situation where science was actually shoved aside, and we researchers just moaned but no one listened. On the other hand it continued to get bandied about that we have no proper links between commerce and research. The problems in establishing these links, however, are in no way exclusive to Slovenia, and everyone, even the most advanced countries, experience them. Those that successfully overcome them have first invested huge efforts and also huge sums of money in this. But for all of them it has paid off handsomely. Now Slovenian researchers would also like finally to take up their role in society, and we also feel a responsibility to contribute to the development of the country – and whom should a country planning more rapid development turn to, if not to its top scientists? Of course we believe, however, that here the state will also for its part provide effective support for science. Recently at the institute we held a consultation, which was attended by around 120 representatives of the commercial sector, for the most part managing directors. We talked about cooperation and we agreed that there is still enormous unexploited scope for this. Now we just have to get on with the work, but of course we need all three players: the research sector, the commercial sector and the state.

This probably also means that you intend to strengthen the proportion of income from the commercial sector. What is it at the moment and what should it be?

According to IJS data, we receive around 16 percent of our income from the local environment, and then there is another share of the same amount from European projects. Together therefore we receive around a third of all our funding, with about two fifths coming from programme financing, and the difference coming from other national projects. In the future we would like to increase both the proportion from the commercial sector – although I would not like to predict what the optimum level should be, indeed this will depend on many factors and in no way simply on our efforts – and the proportion of income from international projects. For these we have more than sufficient opportunity, since every day we receive invitations to collaborate on European projects. No doubt, the fact that Slovenia has a line European Commissioner, and the reputation of our institute, contributes to this. Experience also plays a big part. Although I know this, I am often surprised when I see how extraordinarily successful our researchers are in winning European projects. It would be splendid if we were at least half as successful in winning projects for the domestic economy. Still, if the state fulfils what it announced in the reform proposals, if adequate tax and other incentives are truly provided for development investment by the commercial sector, and if the government policy is the same as indicated in the reform proposals, then we too will reach all the targets we set. But of course under no circumstances will we wait passively to see what happens. At the end of March, as part of the Stefan Days, we intend to invite Minister Damijan and leading business figures to our institute, in order to exchange opinions on what measures could most effectively and most rapidly stimulate development in Slovenia.

Conservation and Management of Wetlands in Slovenia

By Gordana Beltram

We have no right to deprive our children, and future generations, of the benefits we enjoy from the richness and diversity of our ecosystems.

Photo: Arhiv Krajinski park Sečoveljske soline, Notranjski regijski park and Park Škocjanske jame

Gordana Beltram

Introduction

People perceive wetlands in very different ways, but all understand that there can be no wetlands without water, even if the water is not there all the time. They depend on and provide water. Wetland ecosystem diversity and the provision of its services depend on the frequency, quantity and quality of water flowing into, retained in, or flowing from the ecosystem. Wetlands are biodiversity-rich and important as habitats for species that depend on water and for those which share aquatic and terrestrial ecosystems. Being varied and dynamic, they support a great many forms of life. Water is the driving force in wetlands. Water's chemical and physical properties, water regime and biota influence their development and characteristics. Plants and animals form a characteristic biocenosis adapted to the wetland, and particularly to the soil and water conditions. The term is used for aquatic ecosystems, e.g. lakes, rivers or lagoons, but is more common for marshes, peatlands, floodplains and coastal mudflats.

Janez Podobnik, Minister of the Environment and Spatial Planning:

Slovenia is a small country, yet rich in biological and water landscape diversity: various and numerous wetlands spread from the Adriatic coast to Mount Triglav and from the Karst underground waters to the Pohorje bogs and the Mura oxbows. The government has completed and adopted the relevant national legislation and national and international designations to protect the most vulnerable ecosystems and species, yet there is little understanding that human well-being and sustainable development are based on healthy and functioning ecosystems rather than just on economic growth. Slovenia is challenged to halt wetland loss and to reach the 2010 target of significantly reducing biodiversity loss at the national level, thus contributing to achieving the target at regional and global levels. Therefore, we have to act now and strengthen integrated action between all relevant sectors, join forces and assure proper care of nature and the environment. The best way to achieve the target is concerted action. Only through the joint efforts of all actors, from local to governmental levels, research and education institutions, the economic sector as well as NGOs and environmentalists, can good results be achieved. Additionally, lack of awareness of the importance of ecosystem services essentially calls for raising the awareness of all target groups, better conservation and wise use of natural/wetland resources.

Designation of Wetlands of International Importance (Ramsar Convention on Wetlands, Iran 1971) and wise management of resources can contribute to achieving the 2010 target. Due to their special significance, three wetlands in Slovenia have already been included in the Ramsar List, and more areas have been recognised as potential Ramsar sites.

We must ensure that wetlands will continue to provide ecosystem services in the long run. Therefore, all of us who benefit from wetland ecosystem services, whether using these resources, learning from the wetlands or enjoying their beauty, will have to make a concerted effort to ensure their conservation and intelligent use at all levels of planning, implementation of measures and development.

Photo: Peter Skoberne

Janez Podobnik,
Minister of the Environment and Spatial Planning

The Ramsar Convention on Wetlands

Wetlands were among the first ecosystems internationally recognised as being threatened due to human activities and deserving particular consideration. The Convention on Wetlands was developed as an intergovernmental treaty and signed in 1971 in the Iranian city of Ramsar, and is thus commonly known as the Ramsar Convention. Focusing on conservation and wise use of wetlands and their species, it was the first of the global environmental treaties. To date it has provided the framework for national action and international cooperation aimed at conservation and sustainable development of wetlands and their resources.

Accordingly, the Convention broadly defines wetlands as *"... areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres..."* (Article 1). Wetlands include a number of different habitats and are a part of hydrological systems of surface and underground waters. The purpose of the Convention is conservation of all wetlands as part of their catchment areas by maintaining their vital functions, properties and processes to deliver ecosystem services. Functionally, wetlands are connected to and cannot be separated from deep water or terrestrial ecosystems. Therefore the Convention (Article 2) states that the definition of wetlands should also include lakes, rivers, or in other words, standing and running waters and riparian ecosystems.

The Ramsar Convention defines the importance of wetlands according to their ecological, botanical, zoological, limnological and hydrological properties (Article 2.2). "Wetlands of International Importance" (Ramsar Sites) are sites designated under the Ramsar Convention on Wetlands and represent those wetland areas within a country, or areas shared between two or more countries, that are important internationally, but also nationally and locally. Criteria for inclusion in the List fall into two groups: 1-sites containing representative, rare or unique wetland types; 2 - sites of international importance for conserving biological diversity. Ramsar sites are designated *"To develop and maintain an international network of wetlands which are important for the conservation of global biological diversity and for sustaining human life through the maintenance of their ecosystem components, processes and services."* (Resolution IX.1, Annex B)

To date, Ramsar sites have covered a number of different habitat types based on Ramsar Classification System, which includes 42 categories grouped into marine and coastal wetlands, inland wetlands and human-made wetlands. Presently (November 2006), there are over 1630 wetland sites, totalling nearly 146 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance in the 153 Contracting Country Parties to the Convention.

The figure is a relatively small yet crucial portion of all estimated wetland areas. Wetlands are located at all latitudes and altitudes, but the data on their extent differ according to availability as well as the definition used. According to some recent data, wetland ecosystems (including lakes, rivers, marshes and coastal regions to a depth of 6 meters at low tide) are estimated to cover more than 1280 million hectares, an area 33% larger than the United States and 3 times larger than the EU. However, many wetland types are under-represented and there are some geographic regions in particular where further data are needed.

Although to date wetlands have been recognised for their biodiversity values and the critical ecosystem services they deliver for the well-being of human communities *(such as fish and fibre, water supply, water purification, climate regulation, flood regulation, coastal protection, recreational opportunities and, increasingly, tourism)*, they are still among the most threatened ecosystems globally and in Slovenia. More than 50% of specific types of wetlands in parts of North America, Europe, Australia and New Zealand were destroyed during the twentieth century, and many others in different parts of the world degraded. The primary indirect drivers of degradation and loss of inland and coastal wetlands have typically been population growth and increasing economic development. The primary direct drivers of degradation and loss include infrastructure development, land conversion, water withdrawal, eutrophication and pollution, overharvesting and overexploitation, and the introduction of invasive alien species (Millennium Ecosystem Assessment, 2005).

In addition to designation of Ramsar sites, technical and policy guidelines have been developed by the Convention to assist countries in preparing their national wetland policies based on these principles (Ramsar Toolkit). However, action at regional, national and local levels, including appropriate management of the whole *catchment area* (of both surface water and ground water), and the "wise use", that is, sustainable development of wetlands at the national level and through international cooperation are essential for the conservation of dynamic and unstable wetland ecosystems.

Wetlands in Slovenia

In the Slovenian language wetlands have various names such as: čreti(a), blata, barje, jelšev grez, kal, lokva, jezero, loke(a), močvirje, močilo, mlaka, mrtvica, poloj, ponikve(a), poplavni travnik, ribnik, trstičje, vrbina (e), etc. As in English, they all depict particular natural characteristics as well as reflect local uses and different dialects.

Slovenia is rich in water and different landscapes, in biological and cultural diversity. Consequently, Slovenian wetlands are relatively small but diverse and numerous. According to an estimate carried out at the beginning of the century, the percentage of wetlands in Slovenia (including the floodplain areas) does not exceed 5% of the territory (VGI, 2000). The largest among them are wet grasslands, mainly located at Ljubljansko Barje, Cerkniško Polje, Planinsko Polje and Radensko Polje, and at Bloška Planota and Jovse. The most numerous among the natural wetlands are small lakes (including the mountain lakes) and marshes. The intermittent lakes (Lake Cerknica is the biggest) and marshes are the largest for the surface they cover among the natural wetlands. The largest inland wetlands are in the lowlands, i.e. the lower reaches of the rivers (along the rivers Mura, Drava, Sava and Krka) or on karst poljes (the karst catchment of the Ljubljanica with the Cerkniško Polje and Planinsko Polje). Smaller natural wetlands are common on high plateaux (raised bogs at Pokljuka and Pohorje, fens at Bloška Planota). Most of the recorded human-made wetlands are smaller than 0.15 ha (*kali - karstic* pools, clay pits, smaller reservoirs, canals). Sečovlje and Strunjan salinas, Štjuža and Škocjanski Zatok are the only larger wetlands in the Slovenian coastal area. However, many have been destroyed or modified as a result of uncontrolled human activity.

Slovenian wetland policy is mainly based on nature conservation and water management policies, but it also needs to work closely with all the sectors affecting wetland areas (drivers of change). In practice, this means implementation of the Ramsar Convention provisions and resolutions, EU legislation related to wetlands (such as Water Framework Directive, Habitats and Birds Directives), national legislation (such as the Nature Conservation Act, Waters Act, Environmental Protection Act) as well as strategies and programmes developed at the EU or national level. Particular consideration has to be given to wetlands of international importance (designated according to the Ramsar Convention or other international treaties: World Heritage sites or Man and Biosphere areas; Biodiversity important areas in the Medi-

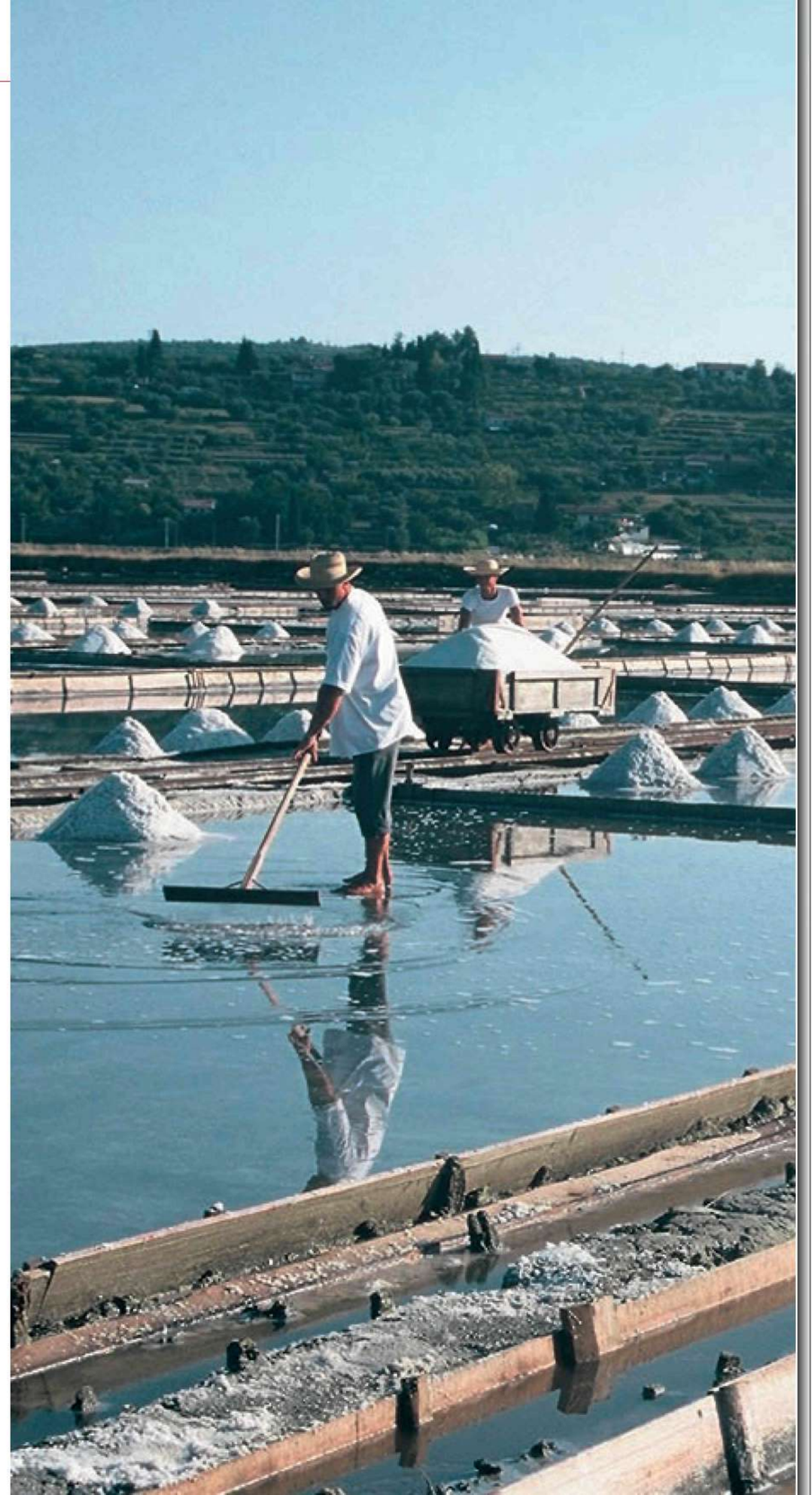
terranean), Natura 2000 sites (EU legislation) and protected areas (national legislation). These areas often overlap yet provide an important network of ecologically and functionally critical ecosystems locally and globally.

As stated in the National Environmental Programme adopted in December 2005, the Ministry of the Environment and Spatial Planning is committed to designating four new Ramsar sites by 2008 (10th Conference of the Parties to the Ramsar Convention). Additionally, the wetland inventory needs to be updated and monitoring of key wetland areas established. Karst hydrological systems (such as the Ljubljanica River) require particular consideration in defining the water management in the entire catchment. An ecosystem approach is considered essential in management applied within wetlands and in their catchments.

Policy measures and actions taken at national (strategies, programmes, legislation) and local levels (management plans) aim at conservation of wetland services and values. In addition to including wetland management in river basins plans, designation of Ramsar sites is a priority for the conservation of Slovenian wetlands of international importance. Their management is based on nationally and regionally established measures and frameworks.

Status of Ramsar Sites in Slovenia

Slovenia notified the Convention in 1992, and Sečoveljske Soline (Sečovlje Salina) were the first wetland included in the List of Wetlands of International Importance. In 1999, Škocjanske Jame (Škocjan Caves) were added as a subterranean wetland site, and in January 2006, Cerkniško Jezero z okolico (Lake Cerknica and its environs) became the third Slovenian Ramsar site representing a complex system of surface and subterranean wetlands. To date, the three Ramsar sites total over 8,200 hectares. Since they critically depend on the water cycle, their catchment areas also need to be considered, and together they cover over 230,000 hectares. The three existing Ramsar sites include a number of different habitat types according to the Ramsar classification system and are important for their biological diversity. Additionally, there are more wetlands in Slovenia that fulfil the Ramsar criteria for inclusion in the list of globally important areas, including: Krakovski Gozd, Jovsi and Dobrava (in the south of Slovenia); the Mura River floodplain and the Drava River with Ormoško Jezero and Šturmovci (in the eastern part); Ljubljansko Barje (in the central part); and the catchment area of Lake Bohinj and Čezsoški Prodi (in the north west of the country).



Sečoveljske Soline (Sečovlje Salina). This is a wetland area at the mouth of the Dragonja River on the Adriatic coast. Sečovlje Salina forms an important part in the network of remaining coastal wetlands in this part of the Adriatic Sea. The salinas of Sečovlje and Strunjan are the two most northern still-active salinas and amongst the very few in the Mediterranean where salt is still harvested manually, as it has been for centuries.

The whole area has been designated the Sečovlje Salina Nature Park and covers 650 hectares in the most southern part of the 46-km coastline, in the community of Piran. Sečovlje Salina is a human-made coastal wetland, particular in its great diversity of fauna, flora and habitats. It has several international designations. In addition to being the first Slovenian Ramsar site, it is an Important Bird Area for wintering, migratory and breeding marine and wetland birds. It qualifies for a Specially Protected Area of Mediterranean Importance (Protocol Concerning Specially Protected Areas and Biodiversity in the Mediterranean, 1995, of the Barcelona Convention, 1976) and it is listed for the network of Natura 2000 sites (according to the EU Habitats and Birds Directives).

Almost the entire protected area of Sečovlje Salina is state property, yet managed by a private enterprise. It consists of two main parts. *Lera* is its northern part, where salt is still harvested. The Canal Grande or Drnica Stream separates Lera from Fontanigge, the Park's southern part. At Lera the crystallisation pans form a smaller but central part, surrounded by the large evaporation pools and concentration basins used for different levels of concentration of seawater. All work in this part is divided between salters (harvesters) and water managers (taking care of the pools and the circulation of sea water). The division of work and rearrangement of the salt making at Lera was introduced by Austrians at the beginning of the 20th century. However, *petula*, a particularity of the salina, has been cultivated for centuries on the bottom of the crystallisation pans. It is a special type of biosediment that prevents the salt crystals from mixing with the sediment and at the same time restrains separate ions from building in the salt.

A human-made coastal wetland, Sečoveljske Soline (Sečovlje Salina) was part of a network of salinas in the North Adriatic that for centuries provided economic and social development of the coastal area and are today an important area of natural and cultural heritage.

At Fontanigge, traditional salt making stopped in the late 1960s and to date is only maintained in an open-air museum, along the canal Giassi and Cavana 131. It shows the water cycle from the sea to the crystallisation pans and the process of salt making as it has been practiced in the salina since the 14th century. It is a cultural monument of national importance and part of the museum (Sergej Mašera) in Piran.

Most of the area of Fontanigge is important for its diversity of habitats such as saline meadows, dry, bare or partially overgrown basins and islets in the large basins, water pools, brackish coastal marsh, mudflats, tidal flats and different habitat types on the banks and reedbeds. Ever since the abandonment of salt making, the salina's infrastructure and the numerous houses have been deteriorating and nature has taken over. In the large basins halophytes dominate and the remains of salters' houses became home to certain animal and plant species.

Salt basins are only rarely covered by the pioneer association of Samphire (*Salicornietum patulae*). Botanically most interesting part of the salina is Fontanigge, with the halophilous meadows and prevailing Glasswort (*Arthrocnemum fruticosum)*. Quite common are also the Sea Purslane *(Halimione portulacoides)* and Common Sea-lavender *(Limonium serotinum*). The margins of the former basins and ditches are covered with *Artemisia caerulescens.* Along the ditches there are individual clusters of Glasswort and Annual Sea-blite (*Suaeda soda*). Golden Samphire (*Inula crithmoides*) coves the banks of the channels.

Among the animal species a characteristic inhabitant of the salt basins is the Brine Shrimp (*Artemia parthenogenetica)*, no more than a centimetre-long, bright red type of plankton. Well adapted to the high salinity of the water in the basins is also the Tooth Carp (*Aphanius fasciatus*). Quite common in the water are the Marine Crab *(Carcinus aestuarii*) and the decapod crustacean *Marsh Shrimp (Upogebia littoralis)*. On the banks of the Dragonja

River, the European Pond Turtle (*Emys orbicularis)* can be seen as well. Quite diverse is the world of insects, reptiles, lizards and snakes, which, however, are not venomous. In the Sečovlje salt pans, the smallest European mammal has also been discovered, the merely 5-cm-long Pygmy White-toothed Shrew (*Suncus etruscus)*. Most common amongst large carnivores is the Beech Marten (*Martes foina*).

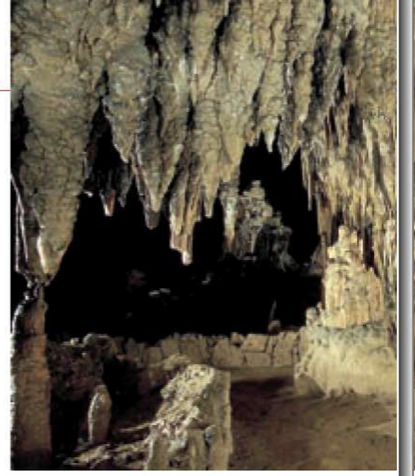
Sečovlje Salina is best known for its birds. There are more than 282 species identified in the area. In Slovenia, five species nest only at this site (including *Sterna albifrons* and *Himantopus himantopus*); there are also several local breeders known to nest only at a couple of other sites in the country. The area is an important wintering and stop-over site for migratory birds (such as *Mergus serrator, Tadorna tadorna* and *Calidris alpina*). The shallow saline water is rich in life, and numerous bristleworms, crustaceans, bivalves, larvae of some fly species and many other creatures make an excellent diet of great variety for the salina's birds.

The main objective of the protected area is conservation of the wetland ecological character, and thus biodiversity and its economic and cultural values (cultural heritage).

To achieve these objectives by:

- Maintaining the saline ecosystem and the diverse habitats that sustain the characteristic flora and fauna;
- Safeguarding the traditional production process and technology of salt making;
- Salt making, which as an economic activity created the salina and was the main development objective in local history.

The Salina is an excellent example of close interaction between the natural environment, cultural heritage and economic production. Cultural heritage has been specially addressed by the open-air museum, but it is also present all over the area in the remains of the salters' houses, canals and dykes, water basins and salt pans. Being one of the two still active salinas in the Gulf of Trieste, its significant value is as a cultural landscape with ethnological, technical, historical and settlement heritage hand in hand with its importance for biodiversity.



The protected area includes various protection measures, of which general ones apply for the entire area, while Fontanigge is considered the core area with very strict nature protection measures, and most of the area is therefore closed to visitors. However, to maintain the salina's characteristics, effective management means maintaining a very delicate balance between different uses of the salina and close cooperation between the three main sectors and the manager of the whole area. Additionally, the main financial support for the area is generated within the area itself. Ever since its protection at the national level in 2001, and particularly after being contracted to a private manager, a remarkably positive change in the maintenance, marketing, conservation and promotion of the area has been undertaken. Nevertheless, there are on-going difficulties in combining all sectoral interests for the benefit of the salina's ecosystem.

Škocjanske Jame (Škocjan Caves) are considered a subterranean wetland, and one of the few areas worldwide with three international designations (World Heritage property, Ramsar site and MAB). The subterranean hydrological system is part of the Karst aquifer, which provides drinking water for a much larger area.

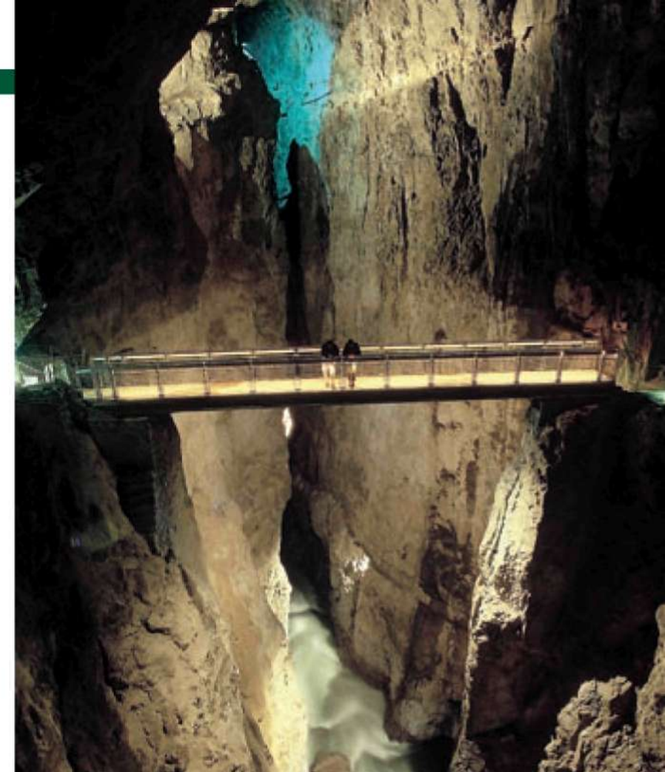
Škocjanske Jame (Škocjan Caves). This is a karst underground water cave system developed in the area of the "classical" Karst (Kras)*. In 1986, the Škocjanske Jame were designated a World Heritage Site due to their exceptional natural values. In 2004, the system became a Karst Biosphere Reserve under UNESCO's Man and Biosphere Programme, particularly in the context of the sustainable use of natural resources. Since 1996, the area has been protected at the national level as the Škocjan Caves Regional Park. It is one of the few areas worldwide with three global designations validating the international significance of the site. The protected area covers only 413 hectares, but its catchment area (buffer zone) extends over 450 km^2.

The surface of the Karst area is very dry and rocky, yet it is an important aquifer. The two collapse dolinas clearly indicate the unpredictability of the underground river. Thus, in addition to their enormous proportions, the main characteristics of Škocjan Caves are underground water flow and the extreme fluctuations of the ground water level. The underground canyon is the central part of the cave system. The so-called Murmuring Chamber narrows into the Hanke Channel (95 m high and only 15 m wide), but then opens into the Martel Chamber, which is among the largest in the world (308 m long, 123 m wide and up to 146 m high). The area is characterized by typical karst phenomena and features developed at the area of contact between permeable and impermeable rock and in the limestone. The three dominant hydrological characteristics include the underground river with a discharge oscillating between 0.050 m^3/s and more than 387 m^3/s (average 8.95 m^3/s); water currents fed by rainwater; and stagnant water gathered in small pools within the cave system. After rainy periods the ground water level regularly rises more than 30 m, but in 1965 an increase of 132 m was recorded. Good knowledge of hydrological phenomena in this system is invaluable for a general understanding of such phenomena in karst areas.

Subterranean flow largely depends on surface flow and the water discharge in the catchment of the Reka River. After sinking into Škocjan Caves (at 317 m above sea level), the river flows underground for 41 km and appears on the surface again in Italy as the Timavo River (Potok). In the Caves, there is a 2.4 km underground river, descending from 317 m above sea level to 214 m at the final sump or siphon. Only 900 m northwest, in Kačna Jama (Kačna Cave), the Reka River flows through the galleries at 182 m above sea level (the inflow siphon is at the altitude of 204 m) and is swallowed at the end sump at 156 m above sea level.

The main hydrological value of the whole system is water storage. Water from this system is used as drinking water for urban areas in Italy. The hydrogeological, hydrogeomorphological and hydrological values could be summarised as follows:

- karstic and surface water drainage from the catchment area;
- formation of characteristic underground karst features;
- karst ponors and springs;
- water storage;
- drinking water supply for urban areas (e.g. Trieste and its suburbs).



Management of this area largely depends on the entire catchment, and any changes in the hydrological character of the catchment can affect the hydrological regime within the caves. Consequently, this can cause irreversible changes in cave biodiversity, which is still poorly researched, and on the economic development of the area. And it can, however, also affect the internationally important karst hydrological system.

Additionally, the karst cave system is important for its biodiversity. The caves are known for the seven species of bats, including the rare and endangered *Miniopterus schreibersi*, that breeds in significant numbers. Recent studies descovered new species of copepods and *Elaphoidella karstica*, described as *E. kieferi* is an endemic species of the caves. In Mejame, belonging to the same subterranean hydrological system, is also a habitat of *Proteus anguinus*. The rocky cliffs in the collapse dolinas in particular are known as a breeding site for *Apus melba,*

Columba livia livia, Bubo bubo and other species. Another characteristic of the collapse dolinas at the entrance to the cave system is the diversity of plant species due to the mixture of the ecological and microclimatic conditions. In addition to predominant Iliric, Dinaric as well as South and Central European floristic elements occurring in a very small area, there are also some Alpine glacial relicts (e.g. *Primula auricula, Saxifraga incrustata, Viola biflora* and *Kernera saxatilis*) and Mediterranean species (*Adianthum capillus-veneris, Asparagus acutifolius, Tortella flavovirescens). Lamium orvala* var. *wettsteinii* is endemic to the Škocjan Caves, while another endemic species *Campanula justiniana* is present at its typical locality (*locus classicus*).

Furthermore, landscape diversity, ecological, historical and cultural values, and economic development of the larger area, add to the Karst Ramsar site. It is an example of excellent practice in motivating and involving the local population, within the protected area and in the catchment.

The Škocjan Caves Management Authority (a public institute) was established in 1996. A management plan has been drafted, which is in the process of adoption. Nevertheless, the institute is very active in working with the locals, and particularly with young people. It has established a network of schools in the entire river catchment, including two schools in Italy. It is an example of cooperative work with the academic and private sectors as well as local people. Although financial support is provided by the state budget, the institute also raises additional funds through a number of international projects. Achieving good results is the best promotion for the area at all levels.

Cerkniško jezero z okolico (Lake Cerknica and its environs). This area is part of the catchment of the Ljubljanica River. The most distinctive parts within a much larger area of Notranjski regionalni park (Notranjska Regional Park) are the intermittent lake Cerkniško Jezero, the karst valley Rakov Škocjan and water cave Križna Jama. While the Ramsar site covers 7510 ha, the surface area of the NRP (buffer zone) totals 222 km^2. The Ramsar site is also an IBA site under the Important Bird Area programme (IBA Cerkniško Jezero and IBA sites Snežnik, Pivka and Javorniki); as such, it has been proposed that it be classified as a Special Protection Area (SPA) according to the Birds Directive and a proposed Site of Community Importance (pSCI) according to the Habitats Directive, to be included in the Natura 2000 network. It also coincides with the Ecologically Important Area (EPO) and includes natural values of national and local importance (natural heritage) according to the national Nature Conservation Act. Additionally, the Ramsar site includes five nature reserves (Zadnji Kraj, Dujice, Osredki, Levišča and Vranja Jama) at Cerkniško Jezero and two natural monuments (Rakov Škocjan and Zelške Jame) within Notranjska Regional Park. Rakov Škocjan has also been protected as a landscape park since 1949, but it is currently included in Notranjska Regional Park as a natural monument.

The area is situated in calcareous rocks, yet much higher than the classical Karst, and forms a part of the Dinaric Mountains. The whole karst catchment of the Ljubljanica is characterised by a series of karst poljes (Cerknica, Planina) and water caves (Križna Jama). It is extremely rich in surface and subterranean wetlands, and thus in biodiversity, characterised by numerous endemic species, particularly cave fauna. With the exception of karst poljes, the area is mostly covered by forest.

The central part of the Ramsar site is Cerkniško Polje. It is the biggest karst polje in Slovenia. A lake forms in the depression during periods of rain (spring, autumn) when the inflow of water is larger than the capacity of the sinkholes to drain the polje. Cerkniško Jezero (Lake Cerknica) is an intermittent karst lake. It has no surface outflow and the main water discharge is through the cave system at the northern edge of the lake. The maximal inflow to the polje may reach up to 240 m^3/s, while the outflow is limited to 40–90 m^3/s. The surface area of the lake ranges between 12 and 26 km^2, but in 2000 it reached 33 km^2. The elevation of the water table oscillates between 547.5 and 553 m above sea level.

Thus the karst polje is a mosaic of different habitats, ranging from permanent water areas through transition areas to purely dryland habitats. The lake is famous for its underground inflow-outflow water system. On the surface, numerous picturesque karst phenomena can be seen such as karst sources and springs, estavelles, ponors and ponor caves. Its constantly changing wetland character is the most typical feature of Cerkniško Polje. In its central part, there is a large reedbed with a plant community of the common reeds *Phragmitetum australis* and *Scirpetum lacustris*. In the areas that are seasonally flooded and where the groundwater level is high, sedge communities of *Caricetum elatae* predominate, whereas the areas that are higher and flooded for a short period are largely covered by sedge communities of *Caricetum gracilis*. At the southeast of the polje there is a small transition mire called Dujice. The water table is high throughout the year, and ecologically the association represents a transition between a fen and a water meadow. At the north, east and south edges of the reedbed there are humid and mesophile grasslands with diverse vegetation.

Vegetation in the lake area differs due to various factors. From the phytocenological point of view, many specious found in the area represent a link between the Central European-Alpine and Illyric (Dinaric)-Submediterranean regions. Fifty-two higher plant species from the Slovenian Red List are found at Cerkniško Jezero. Some other endangered plants or plants of interest that can be found at Cerkniško Jezero are as follows: flowering rush, *Butomus umbellatus*; arrowhead, *Sagittaria sagittifolia*; yellow flag, *Iris pseudacorus*; hedge hyssop, *Gratiola officinalis*; marsh gentian, *Gentiana pneumonanthe*; marsh orchises, *Orchis laxiflora* and *Orchis palustris*; marsh lousewort, *Pedicularis palustris*; fen ragwort, *Senecio paludosus*; bogbean, *Menyanthes trifoliate*; sundew, *Drosera intermedia*; and Alpine cottongrass, *Trichophorum alpinum*.

Cerkniško Jezero is of significant national importance for some 258 bird species identified in the area, of which some 100 are breeders. It is a nesting site for some 60 to 100 pairs of corncrake *Crex crex* (15% of the Slovenian population), a globally threatened species. It is the only nesting site in Slovenia for the red-necked grebe, *Podiceps griseigena,* and the redshank, *Tringa totanus,* as well as for the ferruginous duck, *Aythya nyroca*. For 15 pairs of the common snipe, *Gallinago gallinago,* Cerkniško Jezero is the most important if not the sole nesting site in Slovenia. It is also a habitat of the most important and largest nesting population of the yellow wagtail, *Motacilla flava,* and the reed bunting, *Emberiza schoeniculus*. The quality of habitats as nesting grounds for birds depends on floodwater elevation and dynamics. Among the species of European importance according to the Birds Directive are: the spotted crake, *Porzana porzana*; little crake, *Porzana parva*; bittern, *Botaurus stelaris*; little bittern, *Ixobrychus minutes*; ferruginous duck, *Aythya nyroca*; honey buzzard, *Pernus apivorus*; white-tailed eagle, *Haliaeetus albicilla*; short-toed eagle, *Circaetus gallicus*; barred warbler, *Sylvia nisoria*; and the lesser grey shrike, *Lanius cullurio.*

An outstanding value of Cerkniško Jezero is its richness of amphibians. There are 15 species living in the wider protected area, representing almost 80% of all amphibians living in Slovenia. A remarkable characteristic is Vranja Jama at the southwestern edge of the lake. Over 25,000 common frogs hibernate in this cave, which makes it the world's largest known wintering site of *Rana temporaria*.

Additionally, the lake is rich in ichthyofauna and malacofauna. Of special interest are species that live in the water sources and the subterranean species, of which 10 are endemic to the Ljubljanica catchment area.

Rakov Škocjan, a part of the Ljubljanica catchment area, is a valley formed downstream of Cerkniško Polje by the collapse of ceilings of underground caves. The source of the Rak Stream which flows through the karst valley is at Zelške Jame and the water sinks again at the end of the valley in Tkalca Jama.

The main water sources are Cerkniško Jezero and the Javorniki mountain range. The narrow valley between the caves is mostly covered with a forest of silver fir-beech, a Dinaric forest (*Abieti-Fagetum dinaricum*). More humid sites support oak and beech – *Querco roborri-Carpinetum*. On the occasionally flooded sites on the banks of the Rak grow willows, alders and poplars.

The best-known cave in the area, which is upstream of Cerkniško Polje, is **Križna Jama**. It was first described in 1832. It is renowned mostly for its underground lakes with sinter deposits and remnants of bones of cave-bears that were found in the cave. Križna Jama is also globally important due to its richness of troglobionts. The rare and endemic cave species found in the underground world in the area of Cerkniško Jezero and Rakov Škocjan, predominantly in the subterranean connection between the two of them, and in Križna Jama include the cave beetle, *Leptodirus hochenwartii*, and cave salamander, *Proteus anguinus*, *Pseudocandona pretneri*, *Anophthalmus scopolii*, *Anophthalmus heteromorphus*, *Bathyscimorphus byssinus acuminatus*, *Bathyscimorphus serkoi*, *Bathyscimorphus slavkoi*, *Bathyscimorphus trifurcatus*, *Bathysciotes khevenhueelleri*, *Troglorhynchus anophthalmoides*, *Typhlotrechus bilimeki*, *Machaerites ravasinii*.

At Lake Cerknica and its environs, 36 species of dragonflies are known, 690 beetle species and 127 species of diurnal butterflies. This means that the area is home to 70% of all butterfly species living in Slovenia, or one-quarter of all European butterfly species. Here are found threatened species such as *Maculinea alcon*, *Maculinea teleius*, *Lycaena dispar* and *Euphidryas aurinia*.

Among mammals, the common otter, *Lutra lutra*, and the water schrew, *Neomys anomalus*, living on the banks of the tributaries, depend on the lake's water. The area is also a habitat of the brown bear, *Ursus arctos*; wolf, *Canis lupus*; the European lynx, *Lynx lynx*; and the wild cat, *Felis sylvestris*.

Agriculture and forestry are two main types of land use. Over 55% of the area is covered by forests and 37% by grasslands (meadows and pastures). Additional wetland areas represent 3%, while 2% of the area is arable land. All other land uses together cover just over 3% of the total area. The area is most suitable for extensive agricultural use. It also has great potential for sustainable tourism development.

A management authority has been established for the entire protected area; however, it still lacks some of the key requirements to become fully operational. The main challenge is to prepare and implement a realistic management plan. The priorities are well outlined in the LIFE project (2007–2009) just approved by the European Commission and include defining the sustainable management of the wetland area, raising people's involvement and awareness of wetland values, as well as drafting guidelines for a detailed management plan.

Conclusion

In conclusion, it is important to stress the critical role of wetlands in delivering ecosystem services and their particular contribution to the rich biodiversity of Slovenia. These ecosystems will continue to deliver their services and support life as long as humans use them wisely. Ensuring the future of wetlands and their services requires maintaining the quantity and quality of the natural water regimes on which they depend, and the frequency, amounts and timing of water flows. The Ramsar Convention's "wise use" concept of the 1970s promoted the need for a cross-sectoral approach and integrated management of wetland ecosystems. The year 2007 will mark 20 years of the Brundtland Report defining the concept of sustainable development. Now, using the Millennium Ecosystem Assessment conceptual framework, wise use is still the leading concept for maintaining the ecological character of wetlands in the context of sustainable development. It will ensure the delivery of ecosystem services to support human well-being within Ramsar sites and within their catchment areas as well.

Cerkniško Jezero z okolico (Lake Cerknica and its environs) is not just the largest of the three sites, but also the most complex, including surface and subterranean habitats. This area is part of the karst catchment of the Ljubljanica River, an area particularly rich in endemic subterranean fauna.

The seasonally flooded zones at the north and east edge of Cerkniško Jezero support the association of *Deschampsio-Plantaginetum altissimae* with a variety of species. Considerably large areas are also covered with *Schoeno nigricantis–Molinietum* – a plant community dependent on regular mowing. However, the grass is mowed relatively late in the year, largely depending on the withdrawal of spring flood waters. At the edge of Cerkniško Jezero and at Otok, an association of *Bromo-Brachyopodium pinnati* thrives, while the grasslands on the moderately humid edge with deep soils have been fertilised and support the *Pastinaco-Arrhenatheretum* association. Scrubs that grow along the main stream, the Stržen and its tributaries are characterised by the *Pruno-Ligustretum* association. Scrubs that are present along the entire edge of Cerkniško Jezero form a particular wetland habitat.

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(Endnotes)
*The "classical" Kras/Karst in this context means the original area which gave its name to karst phenomena.

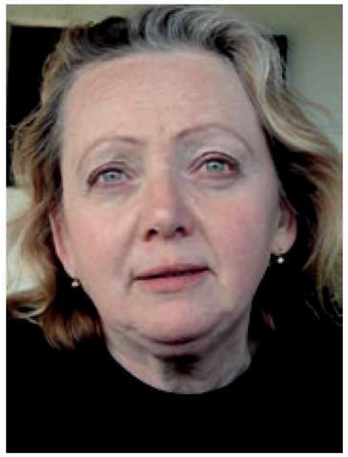
By Gregor Pucelj
DELO

Conserving the otter population in the Goričko area

Once Persecuted, Now Threatened

The Eurasian otter (*Lutra lutra*) has almost been exterminated in Europe over the last 200 years. Although in the last three decades their number has begun to increase, particularly in eastern Europe, it is listed as a threatened species by the Berne Convention and the EU Habitats Directive.

According to data collected to date, there are now up to a hundred otters living in Slovenia. The most concentrated and vital population – estimated at between 30 and 40 individuals – is in the Goričko area. In order to survive the otter needs an unspoilt environment – above all, a freshwater ecosystem. With the building of the new railway line linking Slovenia and Hungary (commenced in 1998 and completed in 2004), which runs through the greater part of the otter's natural corridor through Goričko, an opportunity has presented itself for the more detailed study and long-term protection of the otter. The principal objective: the conservation and improvement of the otter population and the protection of its most important habitats and migration corridors in the area of the "trilateral" nature park comprising Goričko (Slovenia), Őrszeg (Hungary) and Raab (Austria).



Project coordinator Marjana Hönigsfeld Adamič of Lutra.

This is also the title of a four-year project (2004–2008) being conducted by Lutra, the Institute for Conservation of Natural Heritage, with several partners, among them the municipalities of the Goričko area; the project, which has a total value of a million euros, is half funded by the EU within the framework of the LIFE III – Natura project.

Ambassador of a conserved environment

Why specifically the otter, given that other species are threatened too? As project coordinator Marjana Hönigsfeld Adamič of Lutra explains, the otter is a keystone species of freshwater ecosystems and thanks to its characteristic agreeable, charismatic appearance has an important communicating role in shaping environmental consciousness. Thus the otter has become the ambassador of numerous freshwater animal and plant species, a herald of the conserved aquatic environment. Otters once lived in almost every stream, came to every mill, fished in lakes and ponds. If this is no longer the case, this is a sign that we have done something very wrong. And if there are no otters, numerous other species further down the food chain are also at risk.

The main cause is of course the degradation of the environment. In the case of the aquatic environment this is largely the result of work designed to improve agricultural land, including the watercourse regulation projects carried out on a large scale in past decades. Watercourses and standing bodies of water are also affected by pollution in the form of nutrients and biocide residues from agricultural land, and of course by uncontrolled sewage. Another major threat is traffic, with two or three otters killed on the roads every year in Goričko alone.

Several projects more or less connected to environmental protection are under way in the area of the Goričko Nature Park, including: Study of the population/ecological characteristics of deer (2004–2007); Cross-border biodiversity, Phare programme Slovenia–Austria (September 2005–September 2006); Technical groundwork for a management plan for the Ledava basin and Ledava Lake (March 2006–March 2007); Along the green link between Slovenia and Austria (September 2005–September 2006); With a team of horses through Goričko, Phare programme Slovenia–Hungary (September 2005–September 2006); Bukovnica Lake – an awakening beauty, Phare cross-border cooperation programme Slovenia–Austria; the European green ring, INTERREG IIIB (2006–2008).

A fortunate coincidence

The project for the conservation of the otter population in Goričko is fortunate in that the area it covers coincides almost completely with the area of the Goričko Nature Park, which spreads over an area of 462 square kilometres in the extreme north-east of Slovenia between the Austrian and Hungarian borders.

The project, which employs two full-time researchers and a volunteer (co-ordinator Marjana Hönigsfeld Adamič is joined by the biologists Jakob Smole and Tatjana Gregorc), will among other things include an inventory of flora and fauna and habitat types important for the otter. 'Black spots' along the otter's migration corridors will be identified, and a plan for their elimination prepared. Road signs will be put up warning of the presence of otters, and in cooperation with partner organisation Limnos d.o.o. demonstration 'eco-remediations' will be carried out on ten watercourses (or sections of watercourses), in other words they will be restored to their natural appearance. Electric fences will be put up around some fishponds that could otherwise be plundered by an increased number of otters. These fences will prevent otters getting to the water – or rather to the fish. Finally, automatic cameras with infrared sensors will be used, along with the genetic method, to determine the actual number of otters in Goričko.

The biologist Jakob Smole checks one of the eight automatic cameras with infrared sensors used to establish the number of otters in Goričko.

Aqualutra

The logical question is what will happen to the otters when the project ends in October 2008? "We are also thinking ahead," explains Marjana Hönigsfeld Adamič. "Besides the specific conservation goals in the area envisaged for inclusion in the European environmental network Natura 2000, the project is mainly informative and educational in character. We will attempt to realise this in the long term at the Aqualutra centre that we are planning next to the Križevci sports park. The plan includes a traditional Pannonian-style building featuring environmentally friendly materials with good insulating characteristics and energy systems, which we will use to demonstrate ways of saving energy and water. Next to the centre, which will probably be organised and run as a foundation, will be an otter nature trail. Visitors will be able to learn about otters and see their tracks and at the same time learn about the biodiversity of aquatic ecosystems and the sustainable protection and renewal of aquatic habitats."

That they are moving in the right direction is also demonstrated by the enthusiasm of the local population for the conservation and protection of the otter and its environment. In a pilot project on the challenges of Natura 2000 in the local environment, most of the respondents from the Goričko area mentioned the otter in answer to the survey question on which animals came under the protection of Natura 2000 in their area. Another cause for optimism is the fact that the sponsor of the project is the Goričko municipality of Gornji Petrovci has chosen the otter as symbol of the coexistence of nature and human beings and made it part of the municipal coat of arms.

An automatic camera placed under a bridge somewhere in Goričko has 'caught' an otter. Otters are resourceful creatures and they regularly mark their territory with droppings under bridges, where their effect lasts longer because the ground is dry.

Traffic is one of the greatest threats to the otter.

The otter is a carnivorous mammal of the *Mustelidae* family (which also includes weasels, martens and badgers) adapted to life by and in water. They have webbed feet and a strong tail and are excellent swimmers. They are very adaptable in terms of diet: they mainly eat fish but they love freshwater crabs and their menu can also include amphibians, birds, rodents, reptiles and so on. Otters are solitary creatures except during the mating season. The adult male requires a relatively large habitat area (20 kilometres of watercourse), the female slightly less. They protect and mark "their" territory with droppings and therefore establishing the presence of otters is relatively simple. However, since the otter is extremely timid and cautious, human beings hardly ever see

Karl Erjavec, Minister of Defence of the RS:

Undoubtedly one of the most sensitive of the numerous ministries in the Republic of Slovenia is the Ministry of Defence (MORS). Sensitive, because MORS is the largest budget user in Slovenia, and on the other hand because the public believes it should have the right to know everything that happens in ministries, in the country and in the government. To a certain extent this is true, but most of the time it involves confidential data relating to government decisions or is subject to coordination with the headquarters of NATO, of which Slovenia is a member.

MORS undertakes administrative and professional tasks relating to national defence plans, development, organisation, equipment, operation and management of the Slovenian Army, preparation of civil defence, administrative communications and cryptography in the defence system. The ministry pays great attention to military education, organisation, preparation and implementation of the system to defend against natural and other disasters, and the rights and responsibilities of citizens in the defence field, and search and rescue. One strategic goal of the Ministry of Defence is to improve the structure and operation of the national defence system while at the same time continually developing it in line with NATO criteria and standards. Key projects in the defence sector in the near future are:

Karl Erjavec, Minister of Defence of the RS.

- **Continuing** professionalisation of the Slovenian Army (SV) in completing the regular forces and contracted reserves, as well as changes to functional professionalisation and operation of the SV and improving its capacity and readiness.
- **Further strengthening** of our role in the NATO alliance and joint decisions in the concept of collective defence, and participation in peace-support operations based on UNSC resolutions.
- Reorganisation of the administrative part of MORS, which will be comparable to NATO standards.
- **Further elimination** of personnel deficiencies that accumulated during the development of the defence system of the RS.
- **Strengthening** the positive public image of the SV and the defence system.

By moving from a system of conscription to a professional army, we have taken an important step. Today, our solders are professionals who have freely decided to become professional soldiers. Soldiers in the SV are highly motivated professionals looking for career challenges within the military professions, and who have access to the most prestigious military academies.

Together with my team of experts (civilian and military), I have dedicated my mandate as minister to dealing with three key elements:

- completion of the military academy in Maribor and the transfer of military education there;
- organising the military airbase at Cerklje as soon as possible, the opening of which will offer great opportunities for new jobs, particularly for local residents;
- systemic political organisation of control of Slovenian airspace as soon as possible, of course with the desire to control our own skies. I've already received many suggestions and much advice. All, of course, merit more detailed study and analysis.

Photo: Bruno Toič

Development of the education system in the Slovenian Army

What Sort of Soldiers Does Slovenia Send on Peacekeeping Missions Around the World?

By Boris Čerin
Photo: Bruno Toič

For a publication like Quark, which covers research and development, we are most interested in research projects commissioned by the Slovenian Army from institutes and company development projects financed by the Slovenian Army or intended for the needs of the Army. Occasionally, as in this paper, we must also reflect on our own development in the Slovenian Army.

At first glance, the major changes that have taken place in recent years are not obvious, since we often only think of training in the use of individual weapons, in which Europe – and of course Slovenia – has a historic

tradition. But such education and training in handling individual weapons is only a small part of the system of education and training in the Army, and it is linked to research work when new weapons systems are introduced and tested. Viewed as a whole, there have been great changes and work in the development area in the Army, at least if we compare the current Slovenian Army with that of 15 years ago, when it started its development after independence.

The fact that overall operation is important, regardless of the conditions or circumstances in which individual battle units find themselves, entails a whole range of demands. This is particularly true since confusion often arises where comprehensive operation is not ensured at all levels. The implications are clear where human lives are at risk – additional casualties, of which there are already too many in crisis areas, particularly where peaceful military missions are involved in crisis regions around the world. To avoid this, we must ensure both suitable education and all relevant preparations and training. These requirements came to the fore even before the Slovenian Army, which despite centuries of historic presence of military training in Slovenia, in the heart of Europe on the fringes of the Balkans, required rapid and strong development of the military education system.

The battalion's commander, lieutenant-colonel Miha Škerbinc.

For the first time, in 2007 Slovenia will send an entire battalion with over 600 soldiers on a peacekeeping mission. Until now, it has been involved in various peacekeeping missions with individual small units attached to larger units from other countries. In fact, through such small units, it has been involved in peacekeeping missions for the last ten years. But this will be the first time it takes on duties involving greater organisational challenges, and they are likely to be joined on their mission by smaller units from other countries. In future, Slovenia will thus participate in peacekeeping missions with both smaller and larger units on the battalion level.

We took the opportunity, as the 10th battalion prepared to leave on a peacekeeping mission to Kosovo, of a press conference showcasing their final exercises on the level of company training, to talk to the battalion's commander, lieutenant-colonel Miha Škerbinc.

QUARK: For the first time, Slovenia is sending an entire battalion on a peacekeeping mission, and you personally are responsible for its operation. During the current exercise, you also checked the battalion on the level of company training. Did you also receive all the relevant education for such a responsible task as has been entrusted to you?

ŠKERBINC: To join the Slovenian Army, you first have to complete civilian education, in my case a university degree from FDV in politics and defence studies. I gained my military education in stages, so that even before I joined the Slovenian Army, as a conscript, I completed training for reserve officers in the previous army. I've now been in the Slovenian Army for 15 years, and throughout that time I've been in a continuous process of education and training, both within the Slovenian Army and abroad. I should particularly mention that in Slovenia I have also completed commander headquarters training, while I also attended the Command and General Staff College in Fort Leavenworth for a year. This is an American school for land forces for tactical and operational command. Over the last 15 years, I have also attended many different seminars and long and short courses abroad, including a course for UN international military observers and a course for officers in peace-support operations.

Here I should particularly mention that in the Army – more than anywhere else – practice is still an important teacher. I have also been involved in foreign missions, in Israel and Lebanon, and participated in the preparation and organisation of almost all others.

As in any other profession, in the Army you also need self-education and individual monitoring of developments in specific professional fields. Before the Slovenian Army had even built a system of military education, we officers had to be highly motivated and inventive to obtain quality literature and to progress professionally.

For myself, I can say that I passed all the required levels of military education, and completed all the required duties in the Army, to achieve the competence framework required for the duties of battalion commander in any member of the NATO alliance. I've been everything from squad commander, platoon commander, battalion sector chief and deputy battalion commander to chief of brigade staff and battalion commander. This year I took command of the 10th battalion, which is scheduled for the peace mission in Kosovo.

One key factor is that the commander is not alone in the battalion. Behind me stand a whole series of experienced officers and NCOs with excellent military education, and in the final phase they are the greatest guarantee of the success of the battalion.

QUARK: Looking back at the Slovenian Army of 1991, what was the situation like then?

ŠKERBINC: When Slovenia became an independent state, it was not without a historic military tradition. We can look a fair way back in history in this sense. More recently, it was then part of Yugoslavia and the training under the criteria of the time. Slovenia also had the system of general people's defence and social self-defence, which was founded on the specifics of its basis and development. It also had a considerable number of centres developing professions and knowledge that, while not military, were useful in crisis situations – I'm thinking about various societies, clubs and organisations. Of course all of the knowledge we had at independence was still far from enough to immediately establish

a modern army on all levels, in terms of both professionalism of staff as regards mastering techniques and organisation. Here it was and remains important that a comprehensive Slovenian military culture be built. This is an area where much work remains.

QUARK: Modern armies follow their standards, encompassing all of their operations in full detail. Were the standards of the Yugoslav army no longer acceptable for the new Slovenian army?

ŠKERBINC: For us they were no longer useful, not fully and not in the long term. But in the area of techniques they still applied until weapons or individual systems were replaced. Replacing standards is a challenging task, and it takes time. In some areas it can happen quickly, but in others this process can be very slow.

Right at the start we took a very serious approach to introducing new standards and we did this without much hesitation. Thus on the Internet we found much military literature from the USA, the UK and other countries. That was the start, so that at the same time as establishing military contacts with these countries, particularly the USA and the UK, we could begin establishing the new organisational foundations of the Slovenian Army.

Today this process is incorporated into our development goals, since this area is now the responsibility of our doctrine and development centres.

QUARK: Slovenia is now in NATO, and your battalion is preparing for a peacekeeping mission in Kosovo. Thus NATO units, like units for peacekeeping missions around the world, are built on common standards, which allows modular combination of various large armed units from different countries. That's why this part of the development undertaken by the Slovenian Army is so important.

ŠKERBINC: Standards cover various, or rather, all areas of operation of the army, and the bulk of them do not even affect tactical units like a battalion. They primarily involve systemic matters or narrowly specific technical standards, standards in the area of communication, command and control, and logistical standards. On the other hand, some of the standards are very specific and applicable to the battalion level. Essentially, the most important aspect is that NATO members adapt or produce doctrine documents to take account of and comply with the provisions of these common standards.

I'd say we introduced standards in the Slovenian Army in two ways: some under the "top-down" principle, with standards introduced when the Ministry of Defence of RS adopted some NATO standard as the Slovenian military standard and issued implementing acts to introduce them, so that they came to us through the chain of command. A second part of the standards we introduced through our work, so to speak "unawares". Say there's a manual of a motorised battalion, which describes the structure, tactics, command and control system, communications system, certain combat support, all of this, then, is precisely stated in the manual under which the battalion acts. This manual thus in implementation encompasses everything that is standardised at some level of NATO. In our case, by using American or British tactical manuals for the battalion, we began introducing NATO standards, since these were doctrine documents for the tactical level of these armies, and thus of course matched NATO standards.

QUARK: The education process is also standardised?

ŠKERBINC: Of course, there are many areas of standardised knowledge and specific standards that must be met through the education process – for example, knowledge of a foreign language. NATO has standard 6001, which defines knowledge of a foreign language. It is first divided into 4 levels, and then each level is divided into knowledge in listening, reading, speaking and writing. For each level, the extent to which you have to master the language is specified. For a non-native speaker, level four is hard to achieve. Then there are other standards and conditions that determine positions in the alliance or for units. For example a standard defines the level of knowledge of a foreign language that is required for a commander of a battalion like ours. All of this is set out very precisely in NATO standards.

At this point I should mention that the Slovenian Army also has a foreign-language centre, primarily for English but also French and German, where we teach not only members of the Slovenian Army, but every year also participants from other countries.

QUARK: What are the basic standards on the NATO level, and which did you have to adopt first?

ŠKERBINC: Military communication, in all areas. Without the ability to communicate, it won't work. This means language, communications systems, orders, symbols and methods of marking, reporting and the form of reports, etc. All of this is very important. The command and control area must be unified. Then of course there are general doctrine matters, general comprehension of operating principles.

QUARK: For UN work, do their standards apply?

ŠKERBINC: The deciding factor is always the umbrella under which the peacekeeping military operations are being undertaken. It could be under the UN, with a greater or lesser role for NATO. If they're fully under the umbrella of the UN, then of course it is important to respect UN standards. UN standards in the tactical area, for instance, are covered in the UN tactical manual. The UN, which has a special department dealing with operations in support of peace, most recently in 2002 categorised and clearly set out the procedures, themes and standards for training in this area. In the Slovenian Army and the battalion we monitor changes in standards and adapt our training accordingly. If we operate under the UN, then this is a guide, both in training and with regards to equipment and preparations.

QUARK: In training units for peacekeeping missions, are there any other requirements for education and training?

ŠKERBINC: Tactics – for either combat or peacekeeping – are both a science and an art. Just as in combat operations, so in stabilisation operations – which include operations in support of peace – operations are first clearly defined through tactical procedures, techniques and procedures. Tasks undertaken in such operations may for instance be patrolling, escorting convoys, escorting VIPs, monitoring transport of people and vehicles, etc. Each of these tasks has defined tactical procedures that must be learnt.

Military knowledge in this area viewed broadly has developed extraordinarily in recent years. A few years ago, apart from the UN tactical manual, it was hard to find any other suitable manual, not just in Slovenia but anywhere. We gained our initial knowledge from practice in 1996, when we were hosted for a month by a Finnish battalion in Lebanon. We then began to take our first courses abroad. Our officers attended courses in Austria, Finland and Switzerland. Thus through international military cooperation we managed to secure additional training, and then transferred all this knowledge into our education system. Today in this field there are already Slovenian manuals and literature.

QUARK: Is your battalion now better battle-trained?

ŠKERBINC: Last year we trained and exercised for combat operations. The battalion must be trained in the full spectrum of operations, from operations in conflicts of the highest intensity all the way to humanitarian operations.

During our last field training we checked training for combat operations of all five companies of the battalion, and they all gained a positive assessment. That means a lot. It's a sign that we're on the right path and a certain guarantee that in October and November, when we are on exercise in Hungary, we will achieve the same results when the whole battalion is assessed and evaluated.

All of these assessments and checks are on the one hand very strict and on the other very realistic. When you're checking such things, there's no point in lying to yourself. In the final phase, decisions to send some unit on a task are taken on the basis of these evaluations and in serious situations, good training and preparation is the greatest guarantee of keeping our soldiers alive.

QUARK: Your battalion has then completed all the relevant education and training?

ŠKERBINC: We've still got some work in training the battalion as a whole. We will do this before we set off for Hungary. We then have intensive training in stabilisation operations and preparation for the mission to Kosovo. Here it will be easier. The battalion has people with experience of various peacekeeping missions. The 10th

battalion as a whole has never been out of Slovenia – this will be the first time – but we've already sent individual smaller units. In 1996, soldiers from our battalion participated in Operation Alba in Albania, we had one platoon in Cyprus from 1997 to 1999, and we've had a constant presence in Bosnia with at least one platoon. Some units of our battalion have already been to Kosovo, but we now face a much more organisationally challenging task. We will have to operate as a whole battalion, with more than 600 people and 150 vehicles. The Slovenian Army will for the first time on exercise in Hungary – as well as later during the mission to Kosovo – face the problem of transporting such a large unit with all equipment over a long distance and across national borders.

QUARK: Looking at the development of the Slovenian Army answers the question as to what sort of people and military units Slovenia is sending on peacekeeping missions to crisis regions. You say that you operate on the basis of NATO standards. What does this mean – that your units are at the NATO level of combat-readiness?

ŠKERBINC: First we must clearly understand the fact that we are in the NATO alliance, and that consequently the training of the Slovenian Army is in some way defined by NATO training. I have a feeling that in the past we compared ourselves much more with other countries than we do today. Certain integration processes are still underway, both for us and the other new members, but of course the most important thing is that we always learn from those with knowledge and especially experience, and that the Slovenian Army today is at such a level that we too already have much to offer others in the alliance.

In the past, I remember in 1996 and 1997 we sent one platoon, at the time still from the MORIS special brigade, on an international military exercise in Louisiana in the US. Even then we knew full well how our units compared to military units from the US and NATO, since we already had individuals in our ranks who had been educated and trained in NATO countries and the US. But confirmation needs checking in the field, at the level of combat units. And so we did, for the first time, and we were successful enough that this exercise confirmed our assessment of the training of our combat units. We could also become more self-confident. Now there are even more such assessments on the international level. In fact, participation in international military exercises is already part of the permanent training of our military units, and part of our assessment of the training of our units. During such exercises, we can evaluate the results of our education system and the quality of training of our units. So far, we have received confirmation of the quality of our work, which of course encouraged us.

QUARK: Will your battalion be combined with smaller units from other countries?

ŠKERBINC: Such combinations are much less problematic now that we have everything based on NATO standards, since other NATO members have their units organised in the same way and likewise operate on the basis of NATO standards. Modular composition is thus very simple. It's entirely likely that we will be joined in Kosovo by smaller units from other countries, most likely a company, that is, around 100 soldiers. I don't see a problem here, since our small units have also participated in the units of other countries, and in future they will join larger units of other countries, if so agreed. In Kosovo for the first time we are taking over command of a military unit on the battalion level.

The key purpose of uniform standards within NATO countries is that combat units from different countries, no matter how they are combined, are always capable of basic functioning as a joint unit. That's the advantage of operating to common standards.

QUARK: What then is the process for forming a battalion for a mission like Kosovo.

ŠKERBINC: Every such mission is unique, and we have to prepare specially for each. Ideally, a unit in preparation for implementing such a task should go through the whole training cycle. By the end of the year, 10.MOTB will complete its training in the operational cycle. The cycle begins with individual training. Of course, for most duties we already have trained people, but for such a task we're starting from the very beginning, by checking each individual. We ensured personal training for all, depending the duties they're expected to carry out, officers for officer duties and soldiers for soldier duties. At this initial level, everyone has to undergo individual training.

Take an officer who has completed his education and passed all courses abroad – he too will have to go through the training process envisaged for the duties he will have in the unit leaving on a mission. In the phase we call consolidation, several transfers are usually carried out in units, and individuals' responsibilities are also often different. Even someone who has already been on a peacekeeping mission and who has certain experience must complete this part of training.

Someone else arrived as a platoon commander, but after the consolidation phase took on the duties of company commander. He of course must have passed a course for company commander, and must have all the required education and sufficient experience, but the company he will command in the battalion is specific. And this phase of individual training must prepare him to be able to operate in this task in this centre, precisely for these duties, and with precisely this equipment and technology. That's the individual phase. A soldier will again receive some personal weapon. We will assign him a vehicle, and to a certain duty – post, where he will spend the next period of this cycle and the next task. When this phase is complete, assessment is carried out; that's the duty of the NCO line, to check individual training of all soldiers. I assessed the officers, while the battalion NCO checked the NCOs. And all of this must be done according to the required criteria and standards, which are written in acts. Everything must be checked, everything from the basic requirement of mastery of a personal weapon, i.e. how a soldier controls the use of his gun and target shooting.

Then follows the second phase of the cycle, collective training, which is again divided into parts. First up is the basic unit, squad, 9–12 soldiers. For instance such a motorized squad has one combat vehicle and an embarkment point. And then a certain amount of time, a certain number of days, is allocated to training this squad. At the end, the training assessment is given by the company commander, separately for each basic unit. At the next level, three squads combine, and training continues for platoons. After this is completed it's the turn of companies, 130 soldiers with 14 vehicles. And on this exercise we completed our training on the company level. Assessment of the company was performed by my superior, commander of the 1st Brigade of SV, Colonel Anton Tunja, who gave us a positive assessment. We now only await training on the battalion level, which we must complete in the next two months; only after we've been given a positive assessment will our battalion be trained for the envisaged duties, that is, the peacekeeping mission.

QUARK: Talking of military peacekeeping missions, is training for working with civilians in crisis regions equally important?

ŠKERBINC: Even during combat training we gain knowledge of international military and humanitarian law. Each combat soldier must learn the prescribed material from this field, since during operations in support of peace they will undoubtedly come into contact with the civilian population. In our peacekeeping mission, the majority of our work will be geared precisely towards work with the civilian population, and we therefore devoted particular attention to suitable education. The Slovenian Army has a special group of well-trained officers for such purposes. Last year we trained over 30 experts in the area of civilian-military cooperation. A considerable number of our officers and NCOs have in the past attended various courses abroad, where they trained for this area.

It is also worth mentioning that the Slovenian Army highly values learning by experience. Therefore all our soldiers and officers who have been on similar missions are included in our training programmes. These soldiers transfer their experience and their findings from previous missions to soldiers before they head out on military peacekeeping missions, who then have considerable information about everything they can expect from the tasks of a peacekeeping mission before they set out.

Soldiers and lower units are primarily trained for work in crisis situations with civilian populations – local residents in individual areas – through exercises like the one today. At each exercise like this covering the area of operations in support of peace, we simulate anticipated individual events during training. During these exercises individual soldiers are also dressed in civilian clothes and play different roles. This makes it easier for a soldier to understand the operations as a whole. Once again, there are certain procedures for crowd control. Again procedures are prescribed, from the most drastic, where force must be used, to those which cover, and which is of primary importance, some positive activities of soldiers, such as humanitarian aid, purely personal help to an individual or resident in a particular area. These missions also involve direct cooperation with local authorities.

We realise that we will always be foreigners wherever we arrive, and you cannot act as an occupier during operations in support of peace. Quite the reverse, military forces are sent to a region to stabilise conditions, and to offer support to civilian authorities, on the one hand, and – exceptionally important – on the other to the civilian population, which is probably in some crisis condition and has probably suffered or is still suffering due to this crisis. In military peacekeeping missions, units are equipped, trained and motivated to offer direct help to the civilian population. Wherever we've been to date, the response of the civilian population to the Slovenian Army has been exceptionally positive.

Srečko Janša, CEO of Slovenian Air Navigation Services, Ltd.

"We, the employees of Slovenia Control, are aware of the significance of each moving point of light on the air traffic controller's screen. It's not just some blip or shifting star, but people, too! And over again every day each one of us starts and ends their work with that awareness. We believe that this is our main job. Looking after people. Caring for safety."

Development of Slovenia Control, Slovenian Air Navigation Services, Limited

Taking Care of People and Their Safety

By Srečko Janša

Despite the latest technical achievements, including the Internet and telephone communication, face-to-face meetings between business partners still remain highly desirable, sometimes even necessary. Due to the overwhelming influence of globalisation, this fact is also increasingly being connected with air traffic. Trips to far-off destinations and interesting contact with people and places thousands of kilometres away from home are becoming increasingly frequent. Even spending holidays at warmer coastal locations once a year is becoming accessible to more and more people due to the phenomenon of low-cost airlines. Of course, we have to bear in mind safety requirements as well, since safety is a priority among passengers. On the subject of safety, we need to note that modern airplanes and airports with hangars for inspection and repair simply don't tell the whole story. Even though they are not as visible, services for air traffic management and control are as important as any other factors. In Slovenia, all air traffic management and control services are the province of the public company Slovenia Air Navigation Services, Ltd.

The development of air traffic in Slovenia and elsewhere is primarily aimed at increasing traffic and upgrading modern systems intended for air traffic management and control. Regarding these facts, our company is facing the difficult mission of continuously increasing capacities for the provision of services and especially working constantly to ensure the highest level of air traffic safety. The company regularly follows all technical developments in this field and is constantly modernising the equipment needed for the provision of services. Apart from that, the company is particularly aware of one factor which is crucial for successful

air traffic management and control – our employees. Employment of new staff takes place in accordance with very strict standards and qualification tests. Selected candidates must undergo a long training period in accordance with the requirements of their respective positions. Current employees face systematic ongoing vocational training. They are additionally motivated by an effective system of reward and promotion.
The need for optimum flexibility is always present in the company. We achieve it via the way the company is organised, which was established when the company Slovenian Air Navigation Services, Ltd. was founded. The operation of the company is much more independent than it was when it was a part of public administration. The company is much more adaptable now, and able to respond faster to individual demands. We are also faster and more efficient in terms of satisfying international regulations. We are more flexible in harmonising the use of airspace between civil and military organisations, on the level of regional or international cooperation and international integration with other providers of air navigation services. All this leads to optimisation and improvement of these services and therefore to a rise in quality and a simultaneous decrease in cost.

Basic activities of Slovenian Air Navigation Services, Ltd.

The basic activity of the public company is the provision of the following air navigation services: air traffic management, aeronautical information and aeronautical telecommunications.
In all our services, air traffic safety comes first. Quality, adaptability and cost efficiency are also characteristics which represent the philosophy of our company.

Development aims

According to the Air Navigation Act, the company adopted a five-year strategic plan in which the entire programme of the company's services is presented. Development goals for the following years include the construction of a new air traffic management and control centre with a control tower, and an upgrading, replacement and expansion of individual subsystems of the automatic system for air traffic management and control. At the same time, we would like to offer high-quality services, further education of our employees and achieve the goals set in the Local Convergence Implementation Plan (LCIP).
Apart from performing basic activities at the international airports of Ljubljana, Maribor and Portorož, where we are continuously increasing the scope of air navigation services, our company has also reached an agreement with the Slovenian Armed Forces to start providing air navigation at Cerklje ob Krki Airport as well. This will also be further upgraded in the future.
At the same time, we have expanded our basic activities to providing flight school services, expert opinions and analysis, and consulting in the field of air traffic management and control as well as other fields. We will continue with active cooperation in regional integration with other air navigation service providers, especially in our joint efforts to optimise and improve services while cutting costs and achieving better efficiency at the same time, in addition to increasing safety.

Slovenian Skies – Slovenian Air Traffic Control

By Jan Jolič

The public company Slovenia Control, Slovenian Air Navigation Services, Limited, which ensures safe and smooth air traffic over the territory of the Republic of Slovenia, celebrated its second anniversary on 1 May 2006.
Since the role this company performs is unique and since with its skilled personnel it can compete with the best companies in the world, it is worth mentioning the short but difficult path our company followed from its very beginnings to the present day.
Until 1991, when Slovenia gained its independence, air traffic management and control were the province of the Federal Flight Control Administration, with its main headquarters in Belgrade. Nevertheless, the Administration was divided into a western part, based in Zagreb (the territory of the Republic of Slovenia was under Zagreb's jurisdiction), and an eastern part, based in Belgrade. Another peculiarity of the system was that it was controlled by the federal army, which appointed the Director of the Administration from within its own ranks.
With independence, Slovenia found itself facing an extremely demanding task: it had to ensure the sovereignty of air traffic, which in terms of technological and personnel availability of that time meant that it started from scratch. Since similar projects around the world take decades to implement, this decision was an extremely bold one.
Slovenia established the National Air Navigation Administration, which in cooperation with the Slovenian diplomatic sector had to ensure that the International Civil Aviation Organization (ICAO) recognized the Slovenian aviation authorities. Other responsibilities of the Administration and diplomacy were: acquisition of the Slovenian aeronautical designation (LJ) recognized at the international level; acquisition of aircraft registration insignias (S5); establishment of basic infrastructure intended for civil and military air traffic management and control; and acquisition of a sufficient number of qualified personnel for the implementation of services.
Our young country settled these issues swiftly and with only a handful of employees from the former federal administration. In a very short period Slovenia trained a sufficient number of personnel, who quickly took over their tasks. At the same time Slovenia managed to ensure control over its own skies with a relatively small investment.
From 1994 on, general technical and human resources development proceeded more or less smoothly and calmly. At the same time an ever-greater need for human resources developed in all areas of technical activity, as well as the need for new and more technically advanced resources. This was of paramount importance if we wanted to follow a trend of a steady and significant increase in air traffic, which became obvious especially after NATO bombardment of the Federal Republic of Yugoslavia and after 11 September 2001 when the USA was under attack.

Jan Jolič

Another turning point was the year 2001, when the first foundations were laid governing the present arrangement of air traffic management and control. At that time, the newly adopted Aviation Act, which Slovenia considered as the part of the acquis communautaire already envisaged the present organization: a regulatory body within the framework of the state authority (Aviation Directorate) on one hand, and the Air Navigation Services and Air Traffic Control provider (Slovenia Control, Slovenian Air Navigation Services, Limited) on the other.
Due to an inadequate organizational structure and having to operate within the civil service system, the initial difficulties became obvious, as it was not possible to keep up with the technological and personnel requirements necessitated by continuously growing air traffic over the territory of the Republic of Slovenia.
Then in 2003 the National Assembly of the Republic of Slovenia adopted the Act on the Provision of Air Navigation Services, which constituted the establishment of the public company as well as the legal framework for its activities. On 1 May 2004, all 127 employees became the core staff of the newly established public company and immediately embarked on the intense implementation of its services. Other important events of that time: an aviation school was established, enabling education and training of our own as well as foreign personnel, of whom almost 35% of the new people were employed in the past two years; technological modernization and the procurement of new equipment are under way; the company is actively participating in the CEATS project; the first preparations for the construction of a new Air Traffic Management and Control Centre have begun, including the most important part – a new automated system as part of the trans-national One ATM System project in which Slovenia cooperates with Austria and the Czech Republic; and the procurement of new radar systems.

Business principle

The company has committed to promoting business excellence based on monitoring and respecting modern market and security demands and standards of service, safety, technology, environmental care and human resources management.

Business future

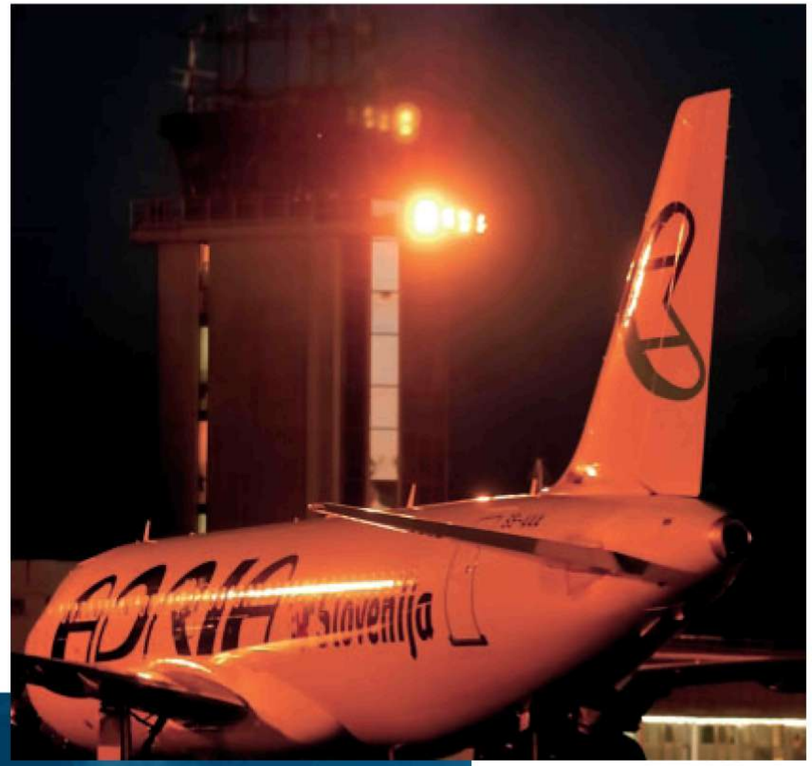
Among the factors which will influence our future business the most, we should mention international coopera-

tion in connecting air navigation services in the region.

A GLANCE INTO THE FUTURE

Future development of the company

One of our central tasks is to modernise infrastructure and systems for air traffic management and control. We intend to follow the requirements of new European legislation, as well as the requirements for an increase of airspace capacity while simultaneously ensuring safety.
With our capacities, we of course will focus on the need for increased air traffic in Slovenia and the region. Along with investment in new equipment, this represents additional job opportunities at expanding airports, such as Maribor, Portorož and the airport at Cerklje ob Krki.
We will continue to examine opportunities and possibilities in terms of



international cooperation and regional integration, harmonisation and integration within the framework of a united Europe (Single European Sky). We will also offer our experience to countries that join the European Union in upcoming years.
Development is very important in our field. Along with constantly meeting the highest requirements of quality and safety, development is solidly a part of all areas of operation (air traffic control, technology, IT, human resources management, etc.) and at all levels of our company's activity. This factor provides us with certain advantages. One of the most important ones is immediate recognition of business opportunities, which is of key importance especially

A new ATCC air traffic control centre with a control tower

The forecast increase in air traffic has brought to the fore the demand for an adequate expansion of airport capabilities. The plan is to create additional aircraft parking areas and new traffic arrangements on ramps. Additionally, the new traffic arrangement envisages the introduction of so-called ground control and airport ground traffic management, which will not be possible to carry out with the current control tower because the expansion of the airport would diminish air traffic controllers' viewing angles needed for airport control. The increase in traffic also entails more work and, accordingly, growth in the number of employees, which means that the demand for additional work spaces are ever-present.
This is the reason that in 2004 the conclusion prevailed that the expansion of the current premises alone would not fulfil all the additional demands of increased air traffic. Preference was given to a two-part comprehensive solution for expansion. The first part involves the modernisation of the current ATM system. The second part is focused on the construction of a new ATCC air traffic management and control centre with a control tower.
In August 2006 the Government of the Republic of Slovenia adopted its 5-year Strategic Business Plan and the investment plan for the above-mentioned project, the implementation of which has already started. The whole project became part of the agenda specifying time periods for each of the operations.
The construction of the new ATCC with the control tower now comprises three parts: The first part involves the construction of the air traffic management and control centre with its accompanying facilities (simulator rooms, restrooms, study rooms, etc.) and other business facilities; the second part comprises the construction of the control tower; and the third part involves the construction of a parking lot with an underground parking garage.
The four-storey control tower will form an integral part of the ATCC building, which in itself will ensure better operability of the building, easier compliance with security requirements and the economy of the construction. This will also facilitate access to common areas and their use. The height of the control tower will give the tower significant functional value, ensuring air traffic controllers a good view of aircraft around the airport and above auxiliary taxiways and parking areas. The addition of a ground traffic management system is also being considered. Such a conception will enable optimal performance of specific activities for which the ATCC and its control tower will have been created.
At the same time the recognisable and symbolic character of the building has not only been considered but is also well expressed.

due to the fact that we want to stand side by side with the best in terms of business processes, and because we want to keep our competitive edge under the new conditions of Slovenian accession to the European Union.
In May 2005, we were among the founders of the European Economic Interest Grouping "One Air Traffic Management System" (OATMS), mainly because this grouping can enable our harmonisation with SES legislation in 2012. As of mid-2006, the grouping has achieved its goals concerning the preparation of necessary documents in accordance with SES regulations. The preparation of all documents should be finished by the end of this year, when the decision will be made concerning the beginning of the second phase of the project, which regards implementation. In the following years, such regional forms of cooperation and integration will be among the key aspects of this field.
We are also cooperating with the Ministry of Transport within the framework of the CEATS project – Central European Air Traffic Services. Bearing in mind that the 1997 concept is outdated, new directions are needed for this project, since despite planned and realised investments, it is now necessary to meet the goals of the Single European Sky.
We will continue to cooperate in other fields as well, such as in founding a suitable entity for training air navigation services staff. We will also continue connecting, i.e. cooperating with, other providers of such services in order to establish a functional block of airspace and to provide all types of aeronautical information.

New air traffic management and control centre

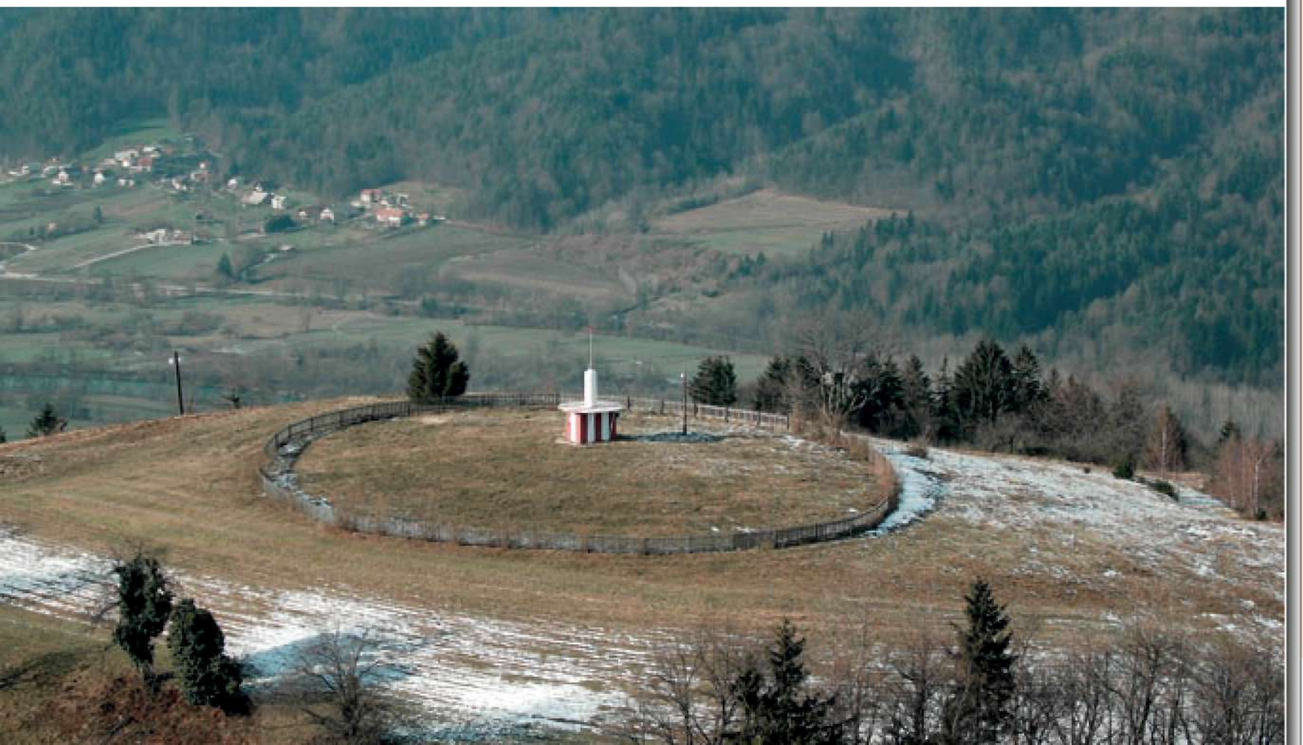
Even before our official founding in 2004, air navigation services were provided from the current location in the centre of Ljubljana. But due to an increase in our activities, this location no longer meets functional norms. This is why we decided to build a new air traffic control centre and to modernise our systems and equipment for air traffic management and control.

First and foremost, two main phases of activity are planned for the following years:

- the construction of a new air traffic control centre with new operations and business facilities and a control tower at Brnik Airport between 2006 and 2008;
- upgrading, replacement and expansion of existing subsystems in the automatic system for air traffic management and control during the same period.

The following activities are planned for the second phase:

- Upgrading radar systems, 2008–2011;
- Replacement of radionavigation and telecommunication systems, 2007–2013;
- Updating and upgrading the systems due to the introduction of interoperability in the years 2011+;
- Introduction of new technologies (multilateration, ADS,...), 2008–2013.



We Intend to Establish a Contemporary School Centre and Offer Our Training Services to Customers Abroad

By Andrej Grebenšek

Andrej Grebenšek

After independence, the Republic of Slovenia also took responsibility for the implementation of air management services. Slovenia inherited only a part of the radio-navigation facilities situated on its territory from the former Yugoslavia, and a handful of people decided to stay and cooperate despite the menacing pressure exerted on them by Yugoslav authorities at that time.
With regard to the fact that the system was built from the scratch (traditionally, air management over Slovenia's territory had been implemented from Zagreb and Belgrade), the personnel recruited were mainly pilots and people working at the airports or in the armed forces.
The first generation of controllers was thus composed of pilots – students, beneficiaries of Adria Airways scholarships, and JLA (Yugoslav People's Army) pilots who joined the Slovene Armed Forces during the Slovene war of independence. Since we had no experience whatsoever, all of the training took place abroad. At almost the same time, several experienced controller instructors from the Zagreb Area Control Centre joined our people, and thus helped with the establishment of the system at home.
In order to become an air traffic controller one does not need extensive prior aviation knowledge, since the expertise required will be gained during appropriate training. The training is so specific, not to mention expensive, that none of the public institutions was willing to support it.
To be able to start training, one must successfully pass a test and complete the selection procedure. The selection of candidates is based mostly on FEAST (First European Air Traffic Control Selection Test Package) results. Training starts with a so-called ab initio course, which lasts approximately three months and comprises the basic subjects that air traffic controllers need to master. Those candidates who successfully complete the training at this stage usually continue their training at a foreign institution in order to acquire a working licence and an airport control instrument rating. During training abroad, which lasts approximately three months, the future controllers gain theoretical knowledge and get trained on a simulator.
Having successfully passed the course, candidates join their future air traffic control units and start with a six-to-twelve month period of practical training. When they accumulate the statutory number of hours, the candidates take an examination to obtain an air traffic controller licence.
Later, candidates may also obtain an approach/approach radar control rating as well as an area/area radar control rating. During training they acquire theoretical knowledge and train on a simulator first, and then start with practical training in one of the air traffic control units. On average, candidates need twelve months for an individual rating.
Air traffic controller candidates must obtain an air traffic controller licence with an airport control instrument rating first in order to acquire the approach and/or area control rating afterwards. Ratings acquired have a one-year period of validity. After that, technical competence for an individual rating is examined either on the job or on a simulator. Should the candidate pass the examination successfully, the validity of the rating is extended for the same one-year period. In this way, training never really ends.
Up until 1 May 2004, air traffic management and control, publication of aviation information and the maintenance of air traffic control systems took place under the auspices of the Civil Aviation Administration of the Ministry of Transport of the Republic of Slovenia. However, following the example of other European countries, a public company Slovenia Control, Slovenian Air Navigation Services, Limited was established on this very date in accordance with European level requirements.
Six months later, an aviation school was set up within the company to take over the responsibility for ATS personnel training, the Aviation Information Service (AIS) and the Communications and Network Service (CNS). In performing its work, the aviation school adheres to international regulations and recommendations (ICAO in EUROCONTROL).
From complete dependence on foreign institutions a little more than a decade ago, we managed to develop our own personnel and all the necessary equipment (classrooms, simulators), and we have thus become self-sustaining. In accordance with European directives governing the Single European Sky and training area, we cooperate with neighbouring air navigation service providers in an effort to standardize procedures and work and training methods as much as possible. This cooperation has led our company to participation in different international projects: among other activities we were in charge of the group which developed the syllabus for training air traffic controllers within the CEATS (Central European Air Traffic Services) area; we also participated in conducting datalink research for the traffic collision avoidance system (TCAS), provided consultancy services to different parties, etc.
The training system is a continuously developing and dynamic system which to a certain extent represents a market niche our company wants to own. When we move to our new premises at Brnik Airport, to be constructed in 2008, we intend to establish a contemporary school centre and offer our training services to customers abroad, mainly in the markets of Central and Southern Europe.

The company is striving to co-finance these investments via funds guaranteed by the EU Cohesion Fund, since the investments fall within the framework of the Modernisation of Air Traffic Management and Control Systems project included in the Operational Programme of Development of Environmental and Traffic Transport Infrastructure of the Republic of Slovenia for the period 2007–2013. The total value of these investments is estimated at EUR 52 M.

Conclusion:

Slovenian Air Navigation Services, Ltd. is qualified for safe, high-quality and efficient provision of air traffic management and control in all aspects of aircraft flight, as well as for safe traffic at airports, provision of necessary aeronautical information and upgrading, implementation and maintenance of systems and equipment for air traffic management and control. In addition, the company has the expert knowledge to prepare regulations in this field. The company is also qualified to participate in Slovenian and foreign projects, to give expert advice and contribute to reaching decisions in favour of the Republic of Slovenia. The establishment of good cooperation with state bodies, especially the Ministry of Defence and the Slovenian Armed Forces, remains an important part of national safety and sovereignty, since air traffic management and control is of crucial strategic importance for Slovenia.

About the ATM System

By Marko Hrastovec

The automated air traffic control system (ATM) is an essential part of the support services provided by Slovenia Control as an Air Navigation Service Provider. The two most important parts of the ATM system are the surveillance data processing system (SDPS) and the flight data processing system (FDPS). The existing ATM system has been in use constantly since 1993. Most of the system was later modernized, apart from the FDPS, which is the most sophisticated component and therefore among the most expensive. Integration of the FDPS and SDPS has been the major development trend in recent years, and we would like to follow that trend as well. In the near future, we intend to replace the FDPS, the only remaining part from 1993. Upgrades are necessary in order to keep up with new demands concerning functionality and to maintain the present level of safety while coping with the ever-increasing demands of traffic.

Marko Hrastovec

About the System

The ATM system is one of the essential components of the equipment regularly used by air traffic controllers. The ATM system provides the necessary data for managing air traffic, such as aircraft position and altitude, direction and speed of flight, callsign and other information used in air traffic control. Lately, "safety net" functions are also an integral part of the system, providing alerts to controllers in case of potentially dangerous situations.

System Description

The automated system is composed of two main subsystems: the flight data processing system (FDPS) and the surveillance data processing system (SDPS). The FDPS provides flight data to controllers, while the SDPS provides data collected from sensors, such as radar, on aircraft position, altitude, speed and direction of flight. These critical data are available at every controller's workstation. The FDPS is the workhorse of any air traffic control system. It transfers flight data between neighbouring control centres and provides and processes various data, such as callsign, entry point, entry level, time of entrance, time of flight over the area of responsibility, speed and type of aircraft, squawk (transponder code used as aircraft ID), flight plan data such as airports of departure and destination, flight routes (itinerary) and other relevant data. Since the system is very complex and it exchanges data with neighbouring control centres and Eurocontrol, it is the most difficult component to replace. It is also one of the most expensive pieces of equipment used in air traffic control.

Hardware for FDPS (and backup SDPS) at Slovenia Control is based on Digital VAX fault-tolerant mainframe computers. The main FDPS application code is written in RTL/2 programming language. Sensors for identifying aircraft positions are mostly radar, with some new systems being currently introduced, such as automatic dependant surveillance (ADS). For safety reasons, at least two SDPSs are required in case of failure of one of them in order to be able to provide uninterrupted service for air traffic controllers. When Slovenia gained independence, there was a need for new radar installations. However, local communities everywhere were very strongly against the use of radar in their environment and thus radar coverage remains only sufficient, as long there is no need for maintenance of any existing radar installation. Otherwise, a reduction in traffic load must go into effect in order to maintain the required level of safety. We also buy data from the Austrian radar installation at Koralpe.

Main Parts

As described above, the system is composed of the FDPS and SDPS. However, these two parts are far from being all that an air traffic controller needs in order to manage the air traffic over his /her area of responsibility. We have already mentioned radar, which sends data to the SDPS. In addition, Air Traffic Controllers communicate with pilots via UHF/VHF radios. VHF radio transmitters and receivers are in place at various locations. Telephone lines with neighbouring control centres and VHF systems are connected to an advanced voice communication system (VCS). All flight plan data come into and go out of the FDPS via the AFTN (Aeronautical Fixed Telecommunications Network) switch. It is connected to the worldwide aeronautical network for data exchange. In order to calculate times regarding a particular flight (time of entering the airspace, time of leaving the airspace, time of flying over sector, etc.), the FDPS also needs meteorological information (wind, etc.). This information comes through the MOTNE link from the Environmental Agency of Republic of Slovenia along with other important meteorological information for air traffic controllers and pilots.

The FDPS is also connected to neighbouring centres via OLDI lines. OLDI stands for OnLine Data Exchange. FDPSs exchange data on flights that are about to enter or leave a certain area of responsibility. Thus, controllers are warned that within a certain time an aircraft will enter their airspace. Slovenia Control has established OLDI connections with Zagreb (Croatia), Vienna (Austria) and Padua (Italy). If an aircraft is coming from Croatia to Austria over Slovenia, the Croatian FDPS will inform their Slovenian counterparts about that flight before the aircraft enters Slovenian airspace, and the air traffic controllers will have all the relevant data at their disposal when they need it. The pilot will be instructed by the Croatian controller to contact Slovenian ATC on a frequency used by the Slovenia Control VHF/UHF equipment. The same would hold true when the aircraft leaves Slovenian and enters Austrian airspace.

Other parts of the ATM system include System Monitoring and Control (SMC) for monitoring all vital components. All data need to be recorded in order to be able to recreate a given situation in case of an accident or other critical situation. RMCDE is a system that converts different radar data, since every radar provider uses a proprietary format. By doing that, a unified format can be fed to the SDPS. An important component not yet represented in the scheme is know as Safety Nets. That system is very important for air traffic controllers, since it monitors traffic and warns controllers about possible critical situations that could lead to an accident. Safety Nets is composed of Short Term Conflict Alert (STCA), which detects potential collisions; Minimum Safety Altitude Warning (MSAW), which detects possible incursions of aircraft into terrain; and Area Proximity Warning (APW), which warns controllers about aircraft approaching prohibited areas.

Future Plans

Slovenia Control is planning to construct a new building for air traffic control in the near future. The facility now being used was set up in 1993, when a quick solution was required. In order to be able to move to the new building, an upgraded and modernised system has to be installed there. The idea would be to use the software already implemented at Slovenia Control and buy new hardware for the new building. However, this is not feasible for the current FDPS, because Digital VAX fault-tolerant computers are no longer available. So to be able to move, a new FDPS must be installed, and to this end, Slovenia Control is now in the process of acquiring a new FDPS that will be more closely integrated with the SDPS in order to provide better usability for controllers. It is designed to use modern, expandable and upgradeable hardware and software platforms. It also introduces electronic strips to replace the printed strips that controllers currently use for flight data. At present, all changes regarding a flight are written on a paper strip, and when a flight is handed over or when the plane lands, the strip is thrown away. The new FDPS will provide a special monitor for every controller showing all the data that was previously on the paper strips. Controllers will then make any changes concerning the flight electronically. By doing so, the system will have more up-to-date information about flights and will be able to perform more precise calculations and processing. Throughput will also be faster and more efficient, enabling safe traffic increases in the coming years.

Even after the move to the new air traffic control centre, development of the system will not stop. Air traffic controllers will gradually migrate to a new "stripless" working environment. More and more functions from the electronic strips will be duplicated on air situation displays. In that way, all functionalities will eventually be consolidated on the displays. Electronic strips will not be needed any more, and they will be abandoned or used only as backup. After this process is completed, the FDPS and SDPS will be tightly integrated and present all data to the air traffic controller on a single screen. And as mentioned at the beginning of the article, this is the trend in traffic control all over the world. Slovenia Control has chosen to take these steps gradually and with as little disruption as possible.

One ATM System News

Austrocontrol forced to leave OATMS

The European Economic Interest Grouping (EEIG) One ATM System – OAMTS was founded in the summer of 2005 by Austrocontrol, ANS CR and Slovenia Control.

The OATMS was intended as a technical and commercial initiative. The participating ANSPs planned to harmonise the phased replacement of the ANSPs' current ATM systems by their jointly developed One ATM System between 2007 and 2012, meaning that it would have been ready for operation during the period 2012–2020. The key benefit of this project was the reduction of the overall cost of implementation and operation of the ATM system for the three partners by at least 20%.

At the request of the Austrian Minister of Transport, Innovation and Technology, Austrocontrol was instructed to withdraw from the European Economic Interest Grouping's "One ATM System – OATMS" by 30 June 2006 for reasons related to the CEATS Project.

The OATMS project had almost completed its first phase, designated a "definition" phase, but due to the lack of Austrocontrol contributions, the project has had to face a delay with respect to its original time frame covering the period from April 2006 onwards.

As OATMS is primarily a technical initiative, technical co-operation between the two remaining partners would still be mutually beneficial. The additional cost of a fallback to a stand-alone solution for the future ATM system is estimated at between EUR 20 and 60 m per partner. The remaining partners in the EEIG's OATMS, namely ANS CR and Slovenia Control, are currently analysing the impact of this situation and have agreed to continue their mutual co-operation to finalise Phase 1 within an agreed new time frame.

Internationally Harmonized and Reliable Measurements:

Inevitabilities for the Sustainable Development and International Competitiveness of a Modern State

By Ivan Skubic, Janko Drnovšek, Nineta Majcen and Irena Grabec Švegl

Dr Ivan Skubic

Assistant Professor
Dr Nineta Majcen

Dr Irena Grabec Švegl

THE ROLE OF A NATIONAL METROLOGY INSTITUTE IN MODERN SOCIETY:

The Metrology Institute of the Republic of Slovenia challenged by present and future measurement needs in the country

Dr Ivan Skubic, Director of the Metrology Institute of the Republic of Slovenia

In developed economies, and in particular countries struggling for existence or for penetration into demanding international markets (Slovenia included), measurement-related activities represent a 3–6 percent share of GDP. In order to ensure adequate traceability of these measurements (including measurements in chemistry) to the prescribed and internationally agreed SI (or if not possible, to other agreed) units, Slovenia needs a well-functioning metrology system.

In any country, especially a developed country, the national metrology institution and the metrology system constitute its key technical quality infrastructure. Although metrological activities are often in the background of other activities, there can be no quality of life (e.g. environment, food, health, technical safety), no quality of Slovenian products and services, no progress and no co-operation with other countries without them. The Slovenian metrology system has therefore from the very beginning established close links with the most advanced metrology systems in Europe and the world in order to acquire knowledge and ensure traceability, to contribute to international comparisons, as well as to participate in joint projects.

The Metrology Institute of the Republic of Slovenia (MIRS) plays the central role in the Slovenian metrology system, covering both scientific and legal metrology. In implementing its mission, MIRS closely collaborates with Slovenian universities as well as with research and other institutes. It is also a participating member in various international organizations in the field of metrology and related activities, both in Europe (EUROMET, WELMEC, AEAO) and worldwide (Meter Convention, OIML, ISO/REMCO).

Being aware of the importance of metrology for the successful and sustained development of the country, MIRS, as a national institution, systematically collects and analyzes national needs in its fields of activity, and through a clear definition of priorities and by taking into account the characteristics of the systems it manages, efficiently provides appropriate Environmenttechnical services.

National implementation of almost 400 EU technical directives and several thousand EU technical standards in all relevant sectors (see Fig. 1) requires confident and precise measurements. Besides, the quality of Slovenian products and services demanded by customers requires even more

METROLOGY: a scientific discipline and infrastructure at the same time

Prof Dr Janko Drnovšek, Chairman of the Metrology Board

Metrology in the European area represents technical infrastructure directly linked to the implementation of directives and hence to the operation of the common European market. On the other hand, metrology is inevitably linked to science and research, from where it actually emerged.

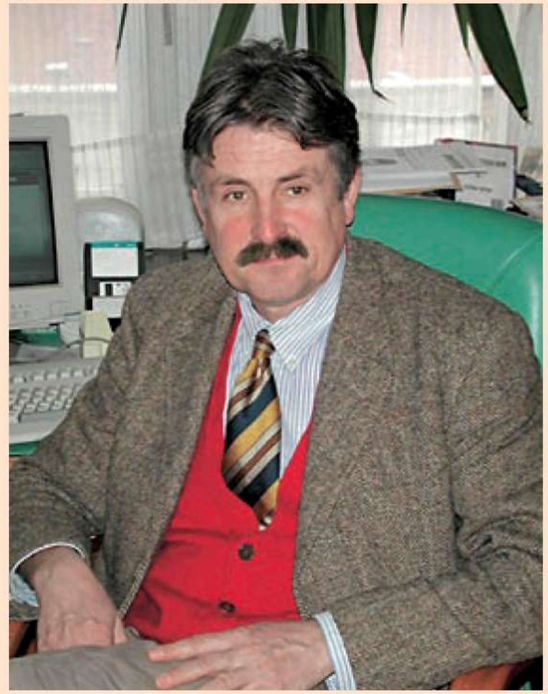
The synergy which has built up over the last years under the umbrella of EUROMET is certainly a key motivator in promoting metrology even further at a time when the field cannot survive in isolation. Obvious proof is the iMERA project, in which all major metrology institutes came together, forming a consortium consisting of European metrology institutes, large and small, cooperating on equal basis. This is of utmost importance for Slovenia and other small countries.

A common European research area, called ERA, is being implemented in various fields. Metrology has already been pivotal in common European projects and welcomes this mutual cooperation of the majority of European national metrology institutes and, generally speaking, European governments.

Implementation of the Metrology European Research Area (iMERA) as an ERA-NET 6th Framework Programme is a project with high expectations. Fusion and sharing of scientific metrology resources for basic and applied research is certainly one of the project's key goals; however, this goal can only be reached if the needs of all stakeholders can be satisfactorily met. The biggest national institutes, which had already led the basic research in metrology, will appreciate the niche expertise of other NMIs since only the complete picture of knowledge, both basic and applied, is a guarantee for metrology to efficiently and successfully implement its fundamental mission of serving the market in the broadest sense with accurate and traceable measurements in all areas.

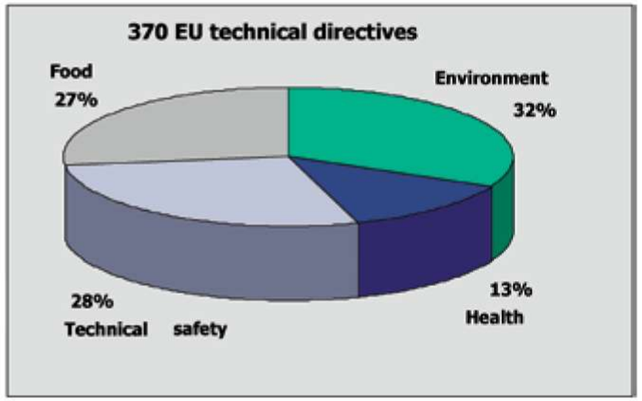
EUROMET, a European collaboration for measurement standards, is one of the most active European associations in the area of measurement and testing, in which Slovenia actively participates in eight out of ten subject areas. In a number of research projects, Slovenia is taking an active role due to the close relations between the national metrology system and the research sector. The Metrology Institute of the Republic of Slovenia (MIRS), part of the Ministry of Higher Education, Science and Technology, co-ordinates metrology activities nationally and represents the metrology system of Slovenia internationally.

As an advisory body to the minister responsible for Metrology, a Metrology Board was established in order to provide an adequate scientific basis and to define national priorities in metrology in Slovenia. The Board works closely with MIRS and co-operates with corresponding bodies elsewhere.



Prof Dr Janko Drnovšek, Chairman of the Metrology Board.

institute is of fundamental importance for successful implementation in this respect. In order to achieve international recognition and to demonstrate full international compatibility and professional competence, MIRS, together with co-operating institutions responsible for national and reference measurement standards, is active in implementing the CIPM MRA through co-operation in many EUROMET (currently 30) inter-comparisons and other projects. In addition, for optimal results in harmonizing the national metrology system with advanced European solutions, MIRS is participating in various projects, especially those of the European Framework Programme and other EU and international projects.
In order to fulfil its basic mission, MIRS, together with co-operating institutions responsible for national and reference measurement standards, provides adequate measurement traceability for the needs of all relevant sectors and ensures adequate knowledge transfer where additional education and training in metrology is needed or where complex or important measurement problems have to be solved.
MIRS is also responsible for managing the national legal metrology system, which covers measuring instruments used in the protection of human and animal health, protection of the environment and general technical safety, transactions in goods and services, and in proceedings before administrative and judicial authorities.
The highest level of metrology, which must be assured by the Government and which is the responsibility of the national metrology institution, is not a market commodity, however. Its adequate functioning is in the public interest, and thus appropriate funding by the Government, at least in the key areas of national need, is of crucial importance to the normal functioning of the entire State.
For the future, we must ensure a capable and flexible national metrology institute, capable of effective international co-operation and responsiveness to the needs of society in both existing and newly emerging fields such as metrology in chemistry, nanotechnology, biotechnology, forensics and anti-fraud protection.
The achievements attained in setting up our national metrology system are the result of 15 years of endeavours, commitments and in-depth work of many individuals. Bearing in mind our vision to establish a fully functional metrology system in independent Slovenia, in accordance with our needs and capabilities, and to become the core of this system, we can claim today, on the fifteenth anniversary of the Slovenian metrology system, to have come a long, successful way towards our final goal.
MIRS, as the Slovenian national metrology institute, is well aware of its responsible role, and today's results represent a commitment to the future as well. On this occasion, I would like to express my sincerest thanks to all who through their fine work and efforts have contributed to the results we have achieved.



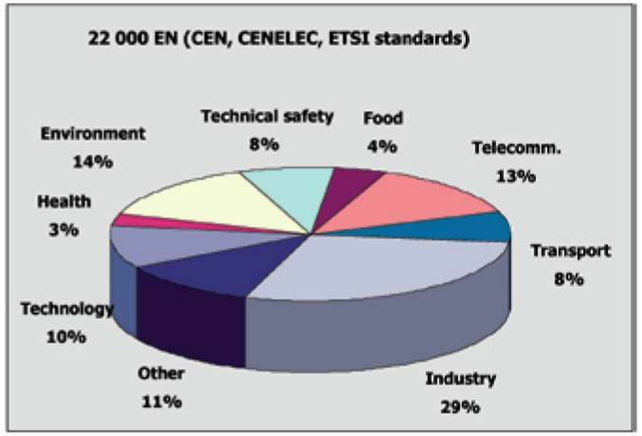


Fig. 1 EU technical directives (without amendments) and EU technical standards, implementation of which requires accurate and confident measurements.

The Metrology Institute of the Republic of Slovenia – Mission Statement

MIRS, the National Metrology Institute of the Republic of Slovenia, is responsible for establishing and managing the national metrology system, which:

- ensures the international compatibility of Slovenia;
- ensures protection of health, environmental protection, general technical safety and consumer protection to the residents of the Republic of Slovenia;
- enables the Slovenian economy to attain global competitiveness.

Responsibilities of the Metrology Institute of the Republic of Slovenia:

- preparing and implementing metrology strategy;
- establishing the national measurement standards system;
- functioning as the national metrological laboratory for specific physical quantities;
- proposing and defining priorities in selecting and financing R&D projects related to metrology;
- managing the legal metrology system;
- managing the precious metals system;
- collaborating with international and other organizations as the representative of Slovenia's national metrology service.

NATIONAL METROLOGY INFRASTRUCTURE IN SLOVENIA: Strong co-operation among the Metrology Institute of the Republic of Slovenia, the universities of Ljubljana, Maribor and Primorska and various research institutes

The metrology system of Slovenia is organized under the Metrology Institute of the Republic of Slovenia (MIRS), the National Metrology Institute. Due to the specific requirements of a small country with very diverse needs for metrology across all sectors of society, a distributed metrology system has proven to be the most suitable solution. This dispersed system was established in order to use all available resources and potentials at various scientific and research institutions within Slovenia dealing with metrology. MIRS, as the responsible institution under the Metrology Act, facilitates and co-ordinates the operation of the entire system within which work in the area of scientific and legal metrology as well as analysis of precious metal alloys is organized. MIRS is also solely responsible for several metrological activities at the highest level. Metrological traceability at the highest metrological level in Slovenia is maintained by the laboratories responsible for national measurement standards, which constitute a uniform system, either within MIRS or in close collaboration with MIRS.
Financially and in terms of expertise, scientific metrology is the most important and by far the most demanding metrological activity in Slovenia. For optimal use of resources, scientific metrological infrastructure, expertise and human resources are shared with legal and industrial metrology whenever possible.
It must be emphasized that legal metrology in EU candidate countries, such as Slovenia, has undergone serious changes, namely transition from overall obligatory type approvals and primary verifications to the new EU practice of one-stop testing. So legal metrology in the case of Slovenia is narrower in its scope of operation but at a significantly higher technical level, and hence it is closer to, and whenever possible shares resources with, the scientific metrology infrastructure, as already mentioned.
The Metrology Institute of the Republic of Slovenia, in respect of the "Rules on National Measurement Standards", has recognized six metrological laboratories for national measurement standards. The quality systems of the laboratories responsible for national measurement standards are in conformity with the SIST EN ISO/IEC 17025 standard. These laboratories, which represent a distributed system of Slovenian national measurement standards, operate within MIRS as well as in different co-operating institutions. Their quality systems are connected to the MIRS overall quality system, which is in conformity with SIST ISO 9001:2000. In this way, their uniform operation, based on the Rules on National Measurement Standards, is assured.

The National Standards of Electric Current and of Time and Frequency

**Slovenian Institute of Quality and Metrology – SIQ,
Tržaška 2, Ljubljana**

The Slovenian Institute of Quality and Metrology (SIQ) operates as an independent, impartial and non-profit organization in the field of metrology (responsible body for the national standards of electric current and of time and frequency, and a calibration laboratory), as well as in the fields of testing and certification of electrical and electronic devices, and assessment and certification of management systems.
The beginnings of SIQ activities go back to 1960, when a specialized industrial institute called the Institute of Automation was founded, which included the development units of the Iskra factories and became a common R&D organization for the entire Iskra group. In a special Measurement and Quality Department, as the central testing and metrology laboratory of Iskra, the Institute started systematically developing quality testing, measuring techniques and maintenance of measuring instruments. This department later became an independent organization called the Institute of Quality Tests and Metrology (IKM), which was renamed the Slovenian Institute of Quality and Metrology (SIQ) in 1992. The SIQ is organized on the model of this type of institution in Europe and the rest of the world, and in accordance with the requirements of relevant standards.

The National Standard of Mass

The Metrology Institute of the Republic of Slovenia – MIRS
Mass Laboratory, Grudnovo nabrežje 17, Ljubljana

The priority activities of the Mass Laboratory, which operates within the Metrology Institute, are ensuring measuring traceability at the international level for the physical quantity of mass and value transfer to the mass standards of a lower hierarchical level in Slovenia. In order to obtain international recognition as the responsible body for the national standard of mass, the laboratory places key emphasis on inter-laboratory comparisons within the framework of the EUROMET organization, as well as with other national institutions. R&D work in the area of the physical quantity of mass allows the laboratory to meet national needs and to maintain adequate proficiency.

Within specified terms of reference, the laboratory also provides other accredited services (calibration of weighing instruments) and performs the most complex tasks in legal metrology.

The National Standard of Thermodynamic Temperature

University of Ljubljana, Faculty of Electrical Engineering, Laboratory of Metrology and Quality, Tržaška 25, Ljubljana

The Laboratory of Metrology and Quality operates within the Faculty of Electrical Engineering of the University of Ljubljana. It was established in 1954 as the Laboratory of Electrothermics and has been operating as the Laboratory of Metrology and Quality since 1992. While the laboratory was developing, and because of the growing importance of quality assurance, it also started dealing with quality control. More than 700 investigations for domestic and foreign companies have been conducted by the laboratory, comprising more than 12,000 pages of documents. The laboratory staff also teach and engage in scientific research within the Faculty.

The laboratory is the responsible body for the national standard of temperature and in addition is the calibration laboratory for temperature and humidity at the highest level in Slovenia. The laboratory was the first in Slovenia, and among the first in Europe, to pass an audit successfully under the new standard for calibration and testing laboratories, SIST EN ISO/IEC 17025.

The National Standard of Length

University of Maribor, Faculty of Mechanical Engineering, Laboratory for Production Measurement, Smetanova 17, Maribor

The Laboratory for Production Measurement has been operating within the Institute of Production Mechanical Engineering of the Faculty of Mechanical Engineering at the University of Maribor since 1968. From the very beginning, the laboratory has been involved in research and development as well as educational work and services in the field of production measurement (measurement of the geometry of work pieces in production) and quality assurance.
The laboratory traditionally cultivates close contacts with Slovenian companies (especially in the metalworking and other industries), helping them to solve practical problems of dimensional measurement. The laboratory conducts research and development projects and provides consulting and training of staff in industry. In addition to maintenance of the national standard, the Laboratory's infrastructure also allows the calibration of standards of length and measuring equipment for the verification of legal measuring instruments.
The laboratory has so far carried out 70 complex R&D tasks within the framework of national and international R&D programs. The bibliography of the laboratory's associates comprises over 300 different publications.

Metrology in Chemistry

Measurement in chemistry is considered to be one of the most extensive and complex fields of metrology. Appropriate support to the national reference laboratories in ensuring adequate traceability, taking into account the needs and priorities of all relevant sectors (environmental protection, protection of health, food, industry ...) is one of the important strategic assignments of the Metrology Institute (MIRS) as required by law. In addition, proper implementation of European technical directives from the stated sectors is of essential importance, not only because of our envisaged future within the EU and general globalization, but also for the quality of each Slovenian's everyday life in the broadest possible sense.
The responsibilities of MIRS in relation to metrology in chemistry are thus related to the following tasks:

- preparation and implementation of the national metrology strategy in chemistry;
- preparation and implementation of policy concerning the use of certified reference materials and reference materials;
- preparation and implementation of policy concerning participation of Slovenian chemical laboratories in inter-laboratory comparisons;
- managing and coordinating the participation of Slovenian chemical laboratories in inter-laboratory comparisons;
- functioning as the national standard laboratory for analysis of precious metal alloys and certain other measurements in chemistry;
- proposing and defining priorities in selecting and financing R&D projects related to metrology in chemistry;
- managing the legal metrology system related to measurement in chemistry;
- preparation of national legislation concerning metrological topics in chemistry;
- proper implementation of European technical directives;
- dissemination of metrological knowledge to analysts and end users of the results;
- collaboration with European and international organizations and representing the national metrology service in these groups;
- active participation in joint EU projects within the 6th Framework Programme of the EU.

Certain specific characteristics of measurements performed in chemistry (like various sample matrixes from environmental, food, clinical and forensic sectors) obviously require similar but distinct metrological infrastructures for chemistry and physical quantities, with clearly defined responsibilities for all parties involved. The main bodies in the national metrological infrastructure in chemistry are the Metrology Institute of the Republic of Slovenia (MIRS), field and reference laboratories, Slovenian Accreditation (SA), Slovenian Institute for Standardization (SIST), universities, research institutes, various regulatory bodies and other end users of the results.
Specific national needs and establishing compatibility with international requirements have imposed certain priorities, among which tasks related to setting up a sound dispersed national metrological infrastructure in chemistry and defining policy in relation to certified reference materials (CRM) and other reference materials (RM) as well as inter-laboratory comparisons are considered the highest.
Research and development activities concerning metrology in chemistry are devoted mainly to detailed studies of various traceability aspects which are still not fully clear and remain debatable in chemistry. Establishing and developing a proper understanding of uncertainty is another important topic, in which international recognizable concepts, as well as specific national needs concerning measurement capabilities, must be taken into account.
At the international level, activities related to traceability in support of research and industry are realized within the EUROMET subject area METCHEM (Metrology in Chemistry), while active participation in ISO/REMCO (ISO Committee on Reference Materials) enables our experts to take part in policy-making related to certified reference materials.
A great deal of effort is constantly being devoted to dissemination of knowledge about the metrological aspects of analytical chemistry. Co-operation with the Institute for Reference Materials and Measurements of the Joint Research Centre of the European Commission (EC-JRC-IRMM) is extremely valuable, resulting in the organization of various events (e.g. roundtable discussions, think shops, workshops) among which courses in the framework of TrainMiC (International Centre for Training in Metrology in Chemistry) are of particular importance. Active participation in and/or the organization of numerous international and national meetings, as well as publishing scientific and expert papers in Messages, Acta Chimica Slovenica and other relevant scientific journals, are also among our essential strategic orientations.

The National Standard of Amount of Substance

The Metrology Institute of the Republic of Slovenia – MIRS Laboratory for Analytical Chemistry, Grudnovo nabrežje 17, Ljubljana

In conformity with the Precious Metal Articles Act (Official Gazette of RS no. 04/06), MIRS functions as the national institution responsible for systematic regulation in the area of precious metals. The MIRS Department for Precious Metals is the leading national laboratory responsible for the chemical analysis of precious metals and maintaining the national standard. Via the application of recently updated measurement equipment (ICP-AES, XRF) for the determination of the volume of precious metals, including recommendations of quality assurance and good laboratory practice, the traceability of measurements of the volume of precious metals at the highest international level has been achieved. The laboratory, organized at the top scientific level, performs R&D work in the field of chemical analysis of precious metals and supports other analytical chemistry laboratories concerned with assaying and determination of precious metals. In addition, quick and accurate performance of chemical analysis and hallmarking service is offered to customers along with control of production.
The laboratory is a full member of the AEAO, Association of European Assay Offices, which enables effective collaboration in various inter-laboratory comparison tests.

Reference alloys for XRF determination of the amount of precious metals

The National Institute of Chemistry – KI

Laboratory for Water Chemistry, Biology and Technology, Hajdrihova 19, Ljubljana

The National Institute of Chemistry is an internationally recognized research organization in the field of chemistry and its related disciplines. It was established in 1946 as the Chemistry Laboratory of the Slovenian Academy of Arts and Sciences. Today, it is a public institution for scientific research and development activities.
Development of analytical, physical-chemical and biological methods for pollution evaluation of surface water is an important activity of the Laboratory for Waste Chemistry, Biology and Technology, which also maintains the national standard for amounts of substances in surface and waste water.

To Promote and Foster Public-Private Partnerships

By Edvard Kobal

The future of Slovenia, as with other Member States of the European Union, resides in the transition from an existing society into a knowledge-based society. Education and research play a key role in this change. Independent investments into education and research are of strategic importance for developing the quality of human resources and for creating new knowledge, and with that knowledge, new products and services in the global market.
The Slovenian Science Foundation, the central national foundation that fosters and promotes science in Slovenia, is aware of its future responsibility – it finds in its work a challenge to provide an environment for high-level science in Slovenia as well as in Europe and the global environment.

The Slovenian Science Foundation in brief

The Slovenian Science Foundation was established in 1994 by the Government of the Republic of Slovenia and 16 other founders, including some of the most prominent Slovenian organisations in research, education, business, finance and the media, to provide the needed stimulus and financial support to the scientific, economic and social development of Slovenia. The SSF is an independent, non-profit institution. It acts as a catalyser, mediator and promoter of science. It encourages the implementation of its own science policy by fostering development of human resources in scientific, research and technological fields by raising the level of intensity of research and development, applied technology and business activity and by implementing a knowledge-based society in Slovenia.
Trade and industrial enterprises have been part of the group of founders since the first year of operation as faithful donors to the Foundation. In the following years, new businesses and individuals have joined in a single common purpose: to foster and promote science, research and education. The Foundation strives for partnerships with the public sector. For the transition of Slovenian society into a knowledge-based society, the Foundation is devoted to implementing projects and programmes whose results help achieve this goal.

In May 2004 the SSF celebrated the 10th anniversary of its founding.

Three thematic areas: aims and actions

1. Independent investments in people

The SSF has developed several financial schemes for collecting financial resources and allocating independent grants to support the personal development and recognition of Slovenian researchers in the international community.

The SSF has named various funds, in the framework of which fundraising has been ongoing and grants allocated, after great Slovenian thinkers and researchers: Herman Potočnik Noordung (fund for natural and engineering sciences), Fran Miklošič (humanities), Martin Pegij (Pegius) (social sciences), Mark Geberc (medical sciences) and Ivan Regen (life and environmental sciences).
The SSF awards independent grants for scientific training, for active participation in scientific events, for the organisation of international science events in Slovenia, and for publishing scientific or popular science publications (the beneficiaries of which are existing researchers). The SSF also awards grants for education (for the benefit of undergraduate and graduate students) at Slovenian and foreign universities.

2. Slovenian science in the European and global environment

The SSF strives to promote Slovenian science in the European context and to foster a process of Europeanisation to give Slovenian researchers a sufficient level of compatibility with researchers from the European Union and Europe in general. It also encourages co-operation with researchers from non-European countries.

Donors are strongly promoted by the SSF every year.

The SSF, with the help of the initiative called "Partnership 2020", acquires donations from different sources, especially from industrial/trade corporations and organisations in research and higher education, to support the participation of Slovenian researchers in framework programmes and pan-European research projects and programmes (European Science Foundation).
With the help of independent funds, the SSF encourages and fosters the co-operation of Slovenian researchers with researchers from non-European coun-

Co-founders of the SSF

- Government of the Republic of Slovenia
- Slovenian Academy of Sciences and Arts
- University of Ljubljana
- University of Maribor
- Jožef Stefan Institute, Ljubljana
- National Institute of Chemistry, Ljubljana
- Krka, d.d., Novo Mesto
- Lek, d.d., Ljubljana (a Sandoz company)
- Gorenje, d.d., Velenje
- Mercator, d.d., Ljubljana
- Petrol, d.d., Ljubljana
- SKB Banka, d.d., Ljubljana (Societe Generale Group)
- Nova Ljubljanska Banka, d.d., Ljubljana
- RTV Slovenia, Ljubljana
- Delo, d.d., Ljubljana
- Gospodarksi Vestnik, d.d., Ljubljana (GV Group, d.d.)
- Open Society Institute Slovenia, Ljubljana

tries, mainly from those with signed memorandums of understanding.

3.Dialogue

The SSF strives to intensify communication and to establish permanent dialogue between researchers, innovators, science managers and the general public.

The SSF began with the organisation of the annual Slovenian Science Festival the year the Foundation was established, and with the organisation of the annual Conference for the Enhancement of Technological Development in 1995. In 2001 the latter was renamed the Noordung Forum (after Herman Potočnik Noordung, 1892-1929, the great visionary and pioneer in researching the possibility of extraterrestrial life).
To advance the ability of Slovenian researchers for communication, the SSF introduced science communication workshops in 2003 that have been implemented by top-level Slovenian researchers and journalists.
Since 2003, the SSF has been awarding the Prometheus in Science Award for Excellence in Science Communication. As of the end of 2005, the prize had been awarded to the group of journalists responsible for the science supplement of the newspaper Delo (2003), Marijan Prosen (2004), Dr Sandi Sitar, Dr Bojan Sedmak, Dr Miha Jeršek, Kvarkadabra/Society for Explaining Science, and the Annales Publishing House in Koper (2005).

The SSF began organising the annual Slovenian Science Festival the year it was founded.

Key competencies of the Slovenian Science Foundation are:

1. Co-ordinating larger projects (e.g. funded by European Commission, United Nations Development Programme).
2. Developing and managing national schemes for financial support.
3. Planning and implementing programmes for training scientists (e.g. science communication workshops, project writing workshops...).
4. Publishing activities (in its own publications).
5. Organising scientific meetings of national, European and global importance and dimension.
6. Planning and implementing the national science festival since 1994, which is financed by the Ministry of Higher Education, Science and Technology of the Republic of Slovenia.

The SSF is the member of the European Science Foundation, European Foundation Centre and European Science Events Association.

The SSF is implementing the National Scholarship Programme of the World Federation of Scientists in Slovenia. It also co-operates with the United Nations, particularly UNESCO and the UNDP. In collaboration with similar organisations it promotes science in Central, South and South-Eastern Europe, as well as on other continents.
Attention is given to establishing and maintaining public-private partnerships in science and innovation
The SSF is the result of the interests and needs of the Slovenian public and private sectors to jointly make investments in science. Consequently, it is understandable for the Foundation to promote and foster mainly public-private partnerships. These partnerships enable investments that help to surpass the role that science has had in Slovenia for several decades. They also enable the gradual integration of members of the Slovenian scientific community into the European context (e.g. framework programmes of the European Union, European Science Foundation).
With the aim of successfully promoting public-private partnerships in science, the SSF is developing communication strategies that will enable synchronized communication with strategic public entities. This type of communication is necessary since the Foundation is striving to establish public-private partnerships in science as an important source of support for developing human resources in the scientific research area, for excellent alternative research projects, for the Europeanisation of Slovenian science, and for the Slovenian "Science and Society" programme.
The private sector (business corporations, citizens) is becoming a more and more active and important partner in the framework of public-private partnerships in science. The representatives of businesses and citizens participate in the creation and development of policies, strategic goals and financial schemes. Organisations and citizens involved in politics are also responsible for providing the needed financial means for independent investments.
The SSF fosters the development and functioning of lasting partnerships between researchers that are mainly financed from the state budget and from businesses. In the establishment and operation of these partnerships, the SSF recognises the future prevailing form of co-operation between the users and implementers of research. The SSF also realises that trust and solidarity in interpersonal and inter-institutional relations are the result of the exchange of ideas, mutual identification of problems and finding optimal solutions.
The SSF has the goal of developing permanent partnerships between industrial corporations and schools (primary and secondary) with the aim of discovering and developing the capabilities of young people for later professional work in research and development in the industrial sector and providing additional training of teachers to enable successful implementation of school curricula and mentoring when introducing students to research work.
Such partnerships can enhance the motivation of young people for studying the natural sciences and contemporary technologies. They also encourage teachers to take additional training and mentoring, and to promote a better understanding of the role of science, technology and industry by teachers and students.
To strengthen public-private partnerships in science in Slovenia, it is particularly important to have good co-operation between the SSF's founders and the media. It is also important to co-operate with media organizations in the form of public campaigns that aim to educate people on the importance of science in society. Public-private partnerships, together with the media, promote and foster the developmental role of science in Slovenian society; the SSF therefore organizes roundtable discussions, presents examples of best practices, and encourages businesses and citizens to join partnerships.
In the first years of the 21st century, the SSF, in co-operation with the media, has supported and fostered the presentation of key Slovenian researchers, developers and innovators. Together with journalists, it has enabled the presentation of their achievements (as well as reasoning) in the form of articles and published roundtable summaries. Hence, the SSF, along with the media, gave researchers and innovators the attention they merited. At the same time, it subtly raised the interest level of readers of specialised newspapers and magazines in issues close to science, key technologies and capital, as well as the connections among them.
In the period 2003-2005, the SSF, in co-operation with the first Slovenian business newspaper Finance, organised several roundtables and published articles about them in the monthly supplement "Science with a Vision":

- 25 November 2003: on university incubators;
- 30 April 2004: on the future of Slovenia in industrial products and services;
- 11 October 2004: on the types and extent of help that Slovenian innovators need;
- 13 June 2005: on public•private partnerships in science and innovation;
- 14 November 2005: on presenting research achievements to the public.

In October the SSF organised the international round table "Women in Science: the connecting and discriminating role of science."

AD FUTURA
Science and Education Foundation
The Vision of Knowledge

By Lidija Honzak

Through its activities, AD FUTURA strives to realise the goals of the Lisbon Strategy to enhance the scope of research work, creativity and innovation as well as to raise the level of technological development in Slovenia. As such, AD FUTURA encourages networking among people involved in education and research, and by providing financial support enhances the mobility of knowledge, ideas and people within the society. The foundation allocates its financial support to extraordinary researchers, faculty and secondary school students from abroad for the purpose of education and research in Slovenia. Part of the funds is also available to Slovene citizens for the purpose of acquiring additional knowledge abroad.

Dr Lidija Honzak, Director.

Education and scientific cooperation of Slovene citizens abroad

The programme of financial support is intended to make studies possible for promising Slovene students and researchers at eminent institutions abroad.
A new feature in 2005/06 is a scholarship intended for Slovene doctoral students in the fields of natural sciences and technology, which makes financial support available for research work at a chosen foreign institution for a period of 3–4 months each year.

Return of Slovene researchers and cooperation with companies

Slovene researchers who have worked abroad for longer periods of time are eligible for AD FUTURA funding in the process of reintegration into the Slovene research sphere.
AD FUTURA provides companies with 50% co-financing of scholarships and help in finding suitable personnel, by which it influences employment policies for individuals who are important for Slovenia's technological and economic development.

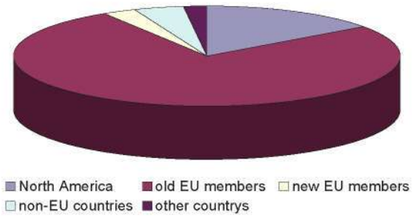
Education and scientific cooperation of foreign citizens in Slovenia

AD FUTURA is expanding the network of prominent foreign researchers and doctoral students involved in strategic research projects in Slovenia.

Support of educational and research policies and information flow

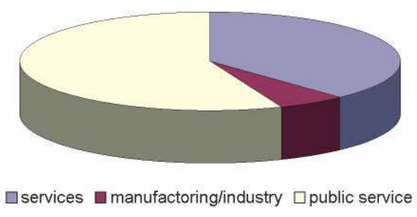
By organising events like the annual Convention of Slovene Students Abroad and the Colloquium of Foreign Students and Researchers in Slovenia, and the online Club AD FUTURA, the foundation encourages the flow of information, facilitates international mobility and influences research and educational policies on national and international levels.
In May 2005, AD FUTURA hosted the European Forum for Early Career Researchers, which was attended by 150 researchers, predominantly from Southeastern Europe. In October, the foundation organised a European festival titled "Science in Film", which featured the best European TV and film productions with scientific content. The festival received an unexpectedly high degree of recognition and interest.
In 2006 AD FUTURA offered an award for the best doctoral dissertation in the fields of natural sciences and technology. Ten doctors of science will receive a one-year scholarship for research work abroad. The first ceremony will be held in November 2006, celebrating the fifth anniversary of AD FUTURA's activity.

AD FUTURA scholarship recipients studying abroad since 2002



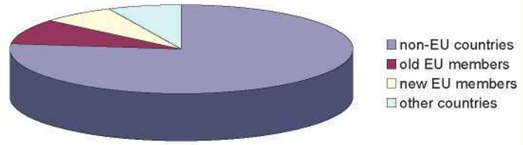
In all calls for applications completed by the end of 2005, AD FUTURA has granted 360 scholarships for undergraduate and postgraduate studies to Slovenes abroad. The majority of scholars choose to study in Great Britain and the United States of America.

Employment of Slovene AD FUTURA scholarship recipients since 2003



So far, 96 AD FUTURA scholars have completed their studies abroad, and no "brain-drain" effect has been seen, as 90% of these scholars return to Slovenia, whereby the majority find employment within the public or service sectors.

Where do foreign AD FUTURA scholarship recipients come from?



By the end of 2005, 120 foreigners had received AD FUTURA funding. In most cases, they choose studies and research work in the natural sciences and technology. The majority of foreigners (78%) come from countries outside the European Union, mainly from Southeastern Europe.

What is AD FUTURA and what is its purpose?

AD FUTURA was established by the Government of the Republic of Slovenia five years ago with the purpose of supporting the training of individuals who will ultimately contribute to the development of Slovenia, mostly in the field of technology. AD FUTURA's primary activity is the funding and co-funding of students and researchers, which is the primary means of achieving the main goal – the support of first-rate scientists and researchers.

What new features have been introduced by AD FUTURA in recent years?

The initial year of the scholarship programme was intended for Slovene students studying abroad. In the years to follow, the programmes and calls for applications expanded and by the second year we managed to attract foreign researchers and students. AD FUTURA has already granted a total of 340 scholarships.
Last year we initiated a project offering 50% co-financing to companies interested in educating suitable personnel.
At the same time we offered assistance in the search for such personnel and educational institutions abroad. We were surprised by the great interest companies showed in the programme. Mostly small and mid-size companies joined the program, which is entirely logical since large companies tend to have their own scholarship sources.
We have also been very successful at subsidiary activities such as networking and information flow. We organise various annual events, such as the annual Convention of Slovene Students Abroad and the Colloquium of Foreign Students and Researchers in Slovenia. It is important for people to communicate with one another, exchange experience and acquire information. Information can also be shared through the AD FUTURA online club, through which members receive weekly news and announcements about funding, education and research. Companies can use the club to attract people with suitable educational backgrounds, which can be of great benefit for a company.
It is interesting that young people are aware of the fact that knowledge is their "ticket to the future", so they are themselves ready to invest in it. Accordingly, the student loans for studies abroad which we introduced last year and which is a first in Slovenia has been a great success. Loans are usually a solution for people who for some reason were not eligible for a scholarship or those who do not wish to be bound by the terms of a scholarship agreement.

AD FUTURA, Science and Education Foundation of the Republic of Slovenia, a public fund
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info@ad-futura.si

And a vision of the future?

We will continue to monitor Slovene national development strategies, which highly prioritises the development of technology. This activity, however, requires specialised personnel. We assess our programmes every year and analyse their effectiveness. This aids us in the creation of programmes tailored to the special needs of our clients. We also aim to contribute to the popularisation of science. As in all European countries, Slovenia has experienced a marked decrease of interest for studies in the natural sciences and technology, and thus we believe it is of utmost importance to present science to the public and to generate interest in technical studies. Our vision of the future definitely includes the further expansion of both our financial and information support programmes.

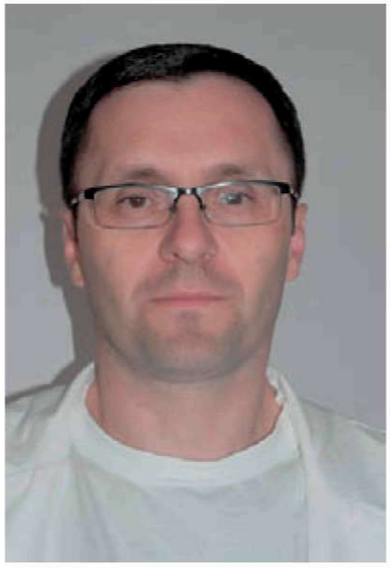
Dr Janez Potočnik, European Commissioner for Science during the official opening of the European Forum for Early Career Researchers and the participants of the "Women in Science" workshop.

Transcatheter Treatment of Congenital Heart Defects Using Amplatzer Devices

By Blaž Kosmač and Tomaž Podnar

Introduction

Congenital heart disease is the most frequent form of major birth defect, affecting nearly 1% of newborn babies. Surgery has been the only treatment option for a number of years. Since the 1970s, transcatheter devices have been available to occlude certain types of congenital heart defects, namely secundum-type Atrial Septal Defect (ASD II), Patent Foramen Ovale (PFO), Patent Ductus Arteriosus (PDA) and, most recently, Perimembranous Ventricular Septal Defect (PMVSD) and Muscular Ventricular Septal Defect (MuscVSD). These devices make possible an alternative to established surgical procedures. The occlusion of these intracardiac and extracardiac communications has been revolutionised by the development of Amplatzer occluders. These devices are made of heat-treated nitinol wire mesh formed into different shapes. At the University Medical Center in Ljubljana, Amplatzer devices have been used regularly since 2000, when the first closures of an ASD II were performed. A total of 171 procedures were performed by the end of 2005.



Assistant Professor Tomaž Podnar, MD, Cardiology Unit, University Children's Hospital, University Medical Center, Vrazov trg 1, 1525 Ljubljana, Slovenia.

Blaž Kosmač , MD, Cardiology Unit, University Children's Hospital, University Medical Center, Vrazov trg 1, 1525 Ljubljana, Slovenia.

Closure protocol

All procedures are performed under general anaesthesia. Patients (both children and adults) are admitted to the hospital the day before the procedure. Provided there are no complications, they are discharged the day after the procedure. Physical examination, ECG, chest x-ray and echocardiogram are performed before the procedure and at follow-up evaluations. The procedures are performed through the groin. Under x-ray monitoring, catheters are inserted through the femoral vein and femoral artery into the heart and large vessels. Defects are precisely delineated by contrast injections and accurate measurements of the defects are performed. In addition, when closing ASD II, PFO or VSDs, an echo probe is placed in the oesophagus to monitor the procedure. An appropriately sized device is selected and positioned through long delivery sheaths introduced through the femoral vein into the defect. Patients are awakened immediately after the procedure. The follow-up protocol includes acetylsalicylic acid, up to 100 mg daily, for six months. Antibiotics during interventions are commonplace, and prevention against bacterial endocarditis is recommended for 6 months until the inserted device is completely covered by tissue.

Secundum-type atrial septal defect (ASD II)

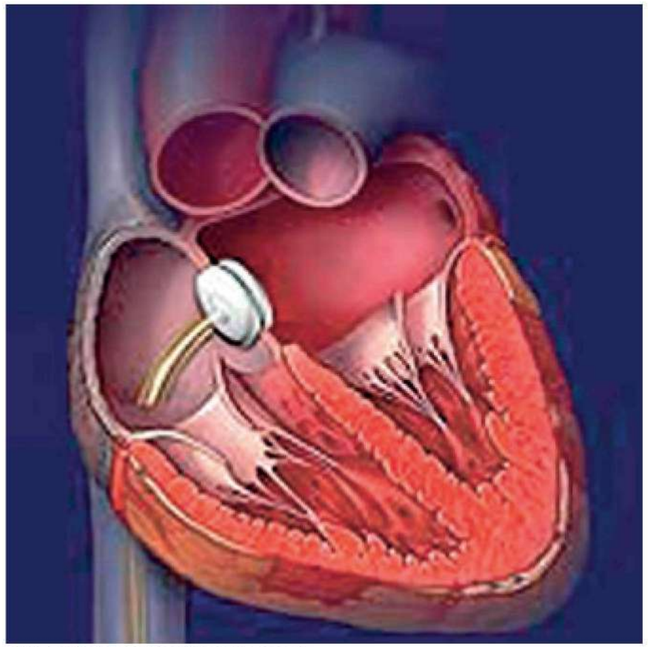
The ostium secundum atrial septal defect is the most common type of atrial septal defect and comprises 6–10% of all congenital heart diseases. There is a low-pressure, left-to-right shunt across the ASD II which causes right heart dilation and pulmonary overcirculation. The indication for closure of the ASD II is clinical or echographic evidence of a significant left-to-right shunt causing dilatation of the right heart chambers. Patients suited to percutaneous closure have defects up to a maximum of 40mm in diameter with sufficient tissue rims (>5mm) surrounding the defect. Very large defects with incomplete tissue rims (except toward the aorta) require surgical closure.

The Amplatzer Septal Occluder (ASO) has the shape of two disks connected by a central stent-like connecting waist,

Figure 1: The three components of the Amplatzer Septal Occluder: left atrial disk, central waist and right atrial disk.

of various diameters to allow closure of both small and large defects (Fig. 1).
The atrial septal defect is sized with a balloon catheter. An occluder of the correct size is selected and introduced into the left atrium via a long delivery sheath. The left atrial disk of the occluder is extended and pulled against the septum. The sheath is then pulled back to deploy the rest of the device – central waist and right atrial disk. After positioning, the device is assessed by transoesophageal echocardiography and then released (Figs. 2 and 3).

The defect is closed by inducing thrombosis on three polyester patches sewn into the device, which become covered by neointima within two months. Until the delivery cable is disconnected, the device can be withdrawn into the long delivery sheath and removed from the body. Immediate complete closure of the defect is observed in most patients, while in the vast majority of the others the residual atrial shunt disappears in the next few months. To date, no other device has achieved such high closure rates, which is attributable to the unique design features and increased thrombogenicity of the device.
Complications of percutaneous ASD II closure using ASO are exceptional and are less frequent than after surgical closure.



ASD occluder positioning in the heart.

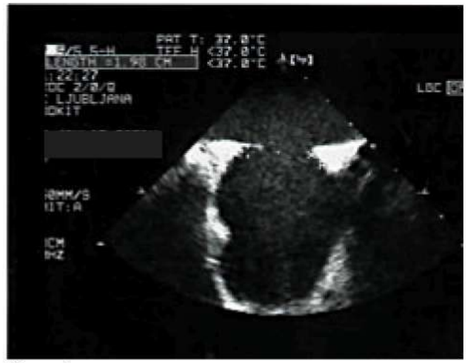


Figure 2

Figure 3

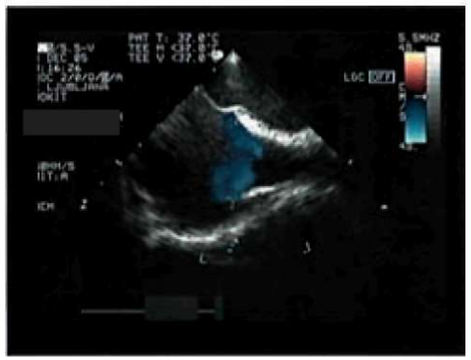
Figures 2 and 3: Transoesophageal echocardiograms of an atrial septal defect measuring aproximately 20mm in diameter before (up) and after (down) occlusion with an Amplatzer Septal Occluder (LA=left atrium, RA=right atrium).

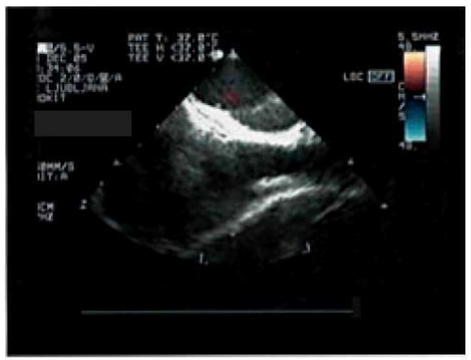
Patent Foramen Ovale (PFO)

The foramen ovale is essential in fetal circulation for blood flow across the foetal atrial septum. After birth, changes in right and left atrial pressures cause functional closure of the foramen ovale. The closure is complete by age two in about 75% of individuals. However, in the remaining 25% the fusion does not take place – the foramen remains patent (Fig. 4). The reasons why PFOs fail to close are unknown, but they likely relate to multifactorial inheritance. The defect is usually oblique and slit-shaped, resembling a tunnel. It is known that PFO carriers are at increased risk for several serious clinical syndromes, including paradoxic systemic embolism such as cryptogenic stroke, acute myocardial infarction, decompression sickness in divers and a rare platypnea orthodeoxia syndrome. It has also been associated with an increased prevalence of migraine, although the causal relationship between the two has yet to be determined. Studies on annual recurrences after a cerebral vascular accident or transient ischemic attack have reported an incidence ranging from 3–16%. PFO alone increases the risk of recurrent events 5-fold, with an even higher risk in the presence of an atrial septal aneurysm. According to various authors, transcatheter PFO closure with present techniques seems to protect against recurrent strokes in this patient population and is currently the only unequivocal indication for PFO closure.
Paradoxical embolisms are demonstrated by transcranial Doppler examination (TCD), while patency with consequent left-to-right and right-to-left shunting is shown by colour flow mapping in transoesophageal echocardiography.

Figure 4: The Amplatzer PFO Occluder. The device differs from the atrial septal defect device in not having a central waist. Its right atrial disk is larger than the left atrial disk and is oriented in a concave direction towards the atrial septum.

Several PFO occluders are currently available on the market; however, Amplatzer PFO Occluders are most often used. The occluder has no central stent and is designed to close the flap-valve of the patent foramen ovale (Fig. 4).
The procedure is similar to ASD II closure using Amplatzer Septal Occluders; however, balloon sizing is usually not necessary during PFO closure (Figs. 5 and 6).





Figures 5 and 6: Colour flow mapping in transoesophageal echocardiography demonstrating spontaneous right-to-left shunting through the slit-like PFO (up). After device deployment, no residual left-to-right or right-to-left shunting is observed (down).

Complications during or after transcatheter PFO closure using Amplatzer PFO Occluders are exceptionally rare.

Patent Ductus Arteriosus (PDA)

Isolated persistence of ductus arteriosus (PDA) accounts for approximately 5% of all congenital heart diseases, although it is seen even more frequently in association with complex heart lesions. The ductus arteriosus is a wide muscular blood vessel joining the left pulmonary artery to the aorta.

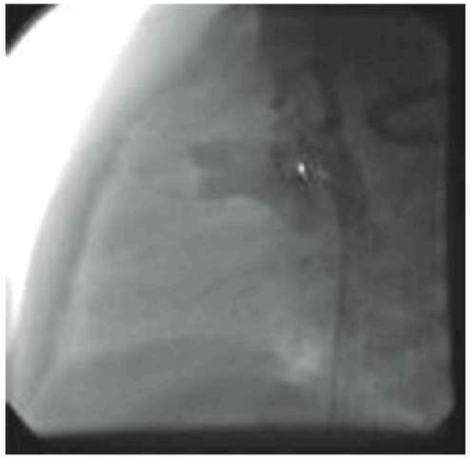


Figure 7: Aortogram showing a large PDA with a shunt of contrast from the aorta to the pulmonary artery.

Figure 9: Repeat aortogram after release of the device showing no significant residual shunting.

This connection allows blood to be diverted from the lungs into the aorta during foetal development, since the baby does not breathe until after delivery. The ductus normally closes within 10 days after birth. If it fails to close, PDA occurs and blood continues to flow from the aorta into the pulmonary artery (Fig. 7).
A PDA is a source of left-to-right shunting causing increased pulmonary blood flow. If it is large, it may cause heart failure, failure to thrive and pulmonary arterial hypertension. More common is a small PDA, presenting as a continuous murmur in an asymptomatic patient. These are closed because of the risk of bacterial endarteritis. Percutaneous closure of the patent ductus arteriosus is the treatment of choice (as opposed to surgery), except in very small neonates, especially in premature babies.
Smaller PDAs are treated by transcatheter coil occlusion. The Amplatzer Duct Occluder is a relatively new device designed to improve occlusion rates of moderate to large PDAs (Fig. 8).

This is a self-expanding mushroom-shaped device, with a thin aortic retention disc designed to secure positioning in the aortic ampulla.

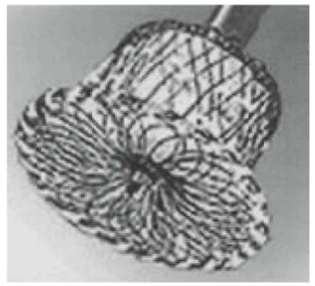


Figure 8: The Amplatzer PDA Occluder is a self-expanding, mushroom-shaped device made from a 0.004-inch thick nitinol wire mesh. A thin retention disc, 4 mm larger in size than the diameter of the device, ensures secure positioning in the mouth of the PDA.

The device is advanced from the venous side through the long delivery sheath across the PDA in the descending aorta, where the retention disk is opened. The retention disk is snugged against the aortic end of the ampulla. Then, the tubular frame of the prosthesis is deployed into the PDA. With the device still attached to the cable, a descending aortogram is performed in the lateral projection to confirm device position. If malposition occurs, the device can be retracted back inside the delivery sheath. When the proper position is confirmed, the device is released (Fig. 9).

The incidence of complications in this procedure is quite low and includes device embolization, incomplete closure, mild left pulmonary arterial stenosis (in the smallest infants) and very rarely haemolysis (secondary to incomplete closure).

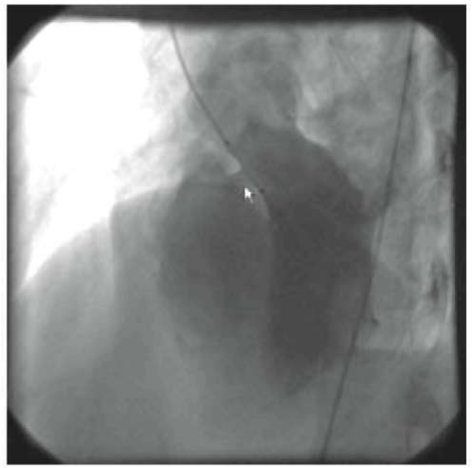


Figure 10: Left ventriculogram showing substantial shunting of dye (arrow) through a perimembranous ventricular septal defect.

Ventricular septal defect (VSD)

Ventricular septal defects account for approximately 20% of all forms of congenital heart disease. More than 70% of all VSDs are perimembranous (PM VSD) and are located in the mid-portion of the ventricular septum (Fig. 10).

Muscular defects (Musc VSD) are located entirely within the muscular portion of the interventricular septum and account for 15% of all VSDs. Ventricular septal defects allow left-to-right shunting of blood and pulmonary overcirculation. Patients with large VSDs present early in life with signs and symptoms of congestive heart failure and failure to thrive. These patients undergo surgical repair. Those with moderate-size defects that can be managed medically are candidates for device closure. The presence of left ventricle volume overload on echo, cardiomegaly on chest x-ray or an episode of infective endocarditis are criteria for device closure.
Percutaneus closure has been described of muscular and perimembranous congenital VSDs. Despite being the most common congenital heart defect, transcatheter closure of VSDs is still an uncommon procedure in most tertiary centres, as it is technically more challenging than that of closing an ASD II, PFO or PDA. It requires the formation of a continuous arteriovenous loop for delivery of the device from the venous side. Further, a perimembranous VSD should have a margin of at least 2 mm from the aortic valve before it can be taken up for transcatheter closure using a modified Amplatzer device (Amplatzer PM VSD Occluder), which has been specially constructed to reduce the risk of any adverse effect on the valves in proximity of the defect – the aortic and tricuspid valves. The first closures of perimembranous VSDs were performed in our centre in autumn 2005, with very encouraging early clinical results (Fig. 11).

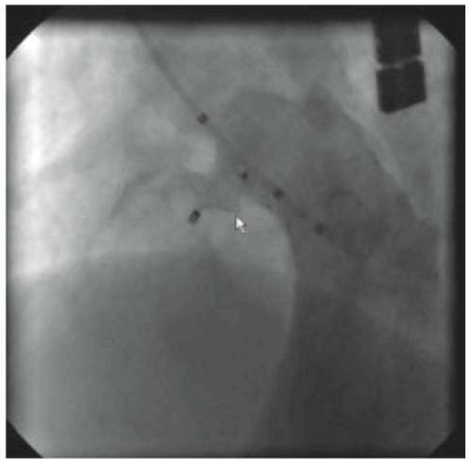


Figure 11: Ventriculogram demonstrating appropriate device position and shape without residual shunt across the defect.

Once the device has been implanted, embolism is a rare occurrence and complete closure can be rapidly achieved in most cases. Valvular regurgitation may occur due to impingement of the device against the affected valve. Ventricular arrhythmias during the procedure and conduction disturbances afterwards are possible. Other rare complications include air embolism and pericardial effusion. However, altogether, complications are rare.

Perimembranous VSD occluder

Conclusion

Since the beginning in the year 2000, much clinical experience has been accumulated by our team at the University Medical Center in Ljubljana regarding transcatheter closure of various congenital heart defects using different types of Amplatzer occluders. Along with the obvious advantages in comparison to surgery, we believe that with careful preselection of patients and careful attention to technical details, transcatheter management of congenital heart defects using different types of Amplatzer occluders is safe and effective.

Characterisation of Lyme Borreliosis Spirochetes

By Eva Ružić-Sabljić

Introduction

Lyme borreliosis is a tick-borne zoonosis caused by a spirochete of the genus *Borrelia*. The isolated spirochete was named *B. burgdorferi* in honour of Willy Burgdorfer, who first reported the spirochete aetiology of Lyme borreliosis in 1981. Later analysis of the Borrelia genome demonstrated that *Borreliae* are not homogeneous, and the former single species was re-classified into several species. Today, twelve different species have been identified, although at least three of them have been demonstrated to cause Lyme borreliosis in humans: *B. afzelii*, *B. garinii* and *B. burgdorferi sensu stricto*. Human pathogen strains that are not identified on the species level are reported as *B. burgdorferi sensu lato.*

Many wild and domestic animals and birds are natural reservoirs of different *Borrelia* species. Because *Borreliae* do not adversely affect their hosts, they can maintain spirochetes for a long time. Different species of blood-sucking arthropods can transmit *Borreliae* from one species to another. Hard ticks of the *Ixodes ricinus* complex are of the greatest significance as vectors. In enzootic foci, a high prevalence of *Borrelia* infection within the animal and tick population can be found. Human infection occurs only if *Borrelia* transmission results from the bite of an infected tick.

Assistant Professor Dr Eva Ružić-Sabljić.

Lyme borreliosis is present in the Northern hemisphere between 33 and 60 degrees latitude, which includes parts of Europe, Asia and America. The global distribution of Lyme borreliosis coincides with the geographic distribution of the main vector, Ixodes ticks, and is considered to be the most frequent tick-borne disease in these parts of the world. Lyme borreliosis is present all over Slovenia, where the incidence is among the highest in Europe.

The pathognomic manifestation of Lyme borreliosis is a skin disorder, erythema migrans, which develops on the skin at the site of a tick bite. *Borreliae* can disseminate from the primary lesion and different organs may be affected (skin, nervous system, joints, eyes, heart, etc.). Multiorgan infection can be indicated by a variety of clinical manifestations with signs and symptoms ranging from mild to severe. Many clinical manifestations are not pathognomic for Lyme borreliosis; in these patients, *Borrelia* infection must be confirmed by microbiological tests.

Description of *B. burgdorferi* sensu lato

Borreliae are typical, highly motile spirochetes 5 to 30 µm long and 0.2 to 0.3 µm wide. The main part of the cell consists of flagella that mediate spirochete motility. Flagella are rigid structures that insert bipolarly and subterminally and overlap in the middle of the cell. A protoplasmic cylinder wraps around the flagella, either left-handed or right-handed. Both structures, flagella and protoplasmic cylinders, are enveloped with a fluid, outer cell membrane containing proteins, lipids and carbohydrates. Although *Borreliae* are slow-growing spirochetes, they can be cultivated in complex rich media.

The *Borrelia* genome is composed of a linear chromosome and different numbers of linear and circular plasmids in the range of 8 to 65 kb. *Borreliae* are the only spirochetes and one of the rare bacteria species that contain a linear chromosome. Additionally, the *Borrelia* chromosome is characterised by its small size of about 1 Mb and by low G + C content of 27 to 32 mol%. *Borreliae* carefully maintain the plasmid copy number, and control plasmid replication, so *Borrelia* plasmids can be observed as minichromosomes. Comparing plasmid profiles of isolated strains, it is evident that the plasmid content varies significantly.

Analyses of whole cell lysates from *B. burgdorferi* sensu lato strains show numerous *Borrelia* proteins. Strains isolated from various biological sources in the same restricted geographical area can differ in terms of the proteins they express and the amount of expressed protein. The molecular weight of a particular protein can also vary among strains. Many *Borrelia* proteins share antigen characteristics on their surface, and in the great majority of hosts *Borrelia* antigens are capable of stimulating the immune system for specific antibody production. The common *Borrelia* antigen is flagellin, a genus-specific polypeptide of 41 kDa. Polypeptides of 100 kDa, 39 kDa and outer surface proteins (Osp) with variable low molecular weights (36 to 22 kDa) are considered to be species-specific antigens. OspA, OspB and OspC are of primary importance for *Borrelia* pathogenesis. The antigen heterogeneity of the major *Borrelia* proteins must be considered with respect to serodiagnosis, immune prophylaxis, taxonomy and pathogenesis.

Methods for *B. burgdorferi sensu lato* characterisation

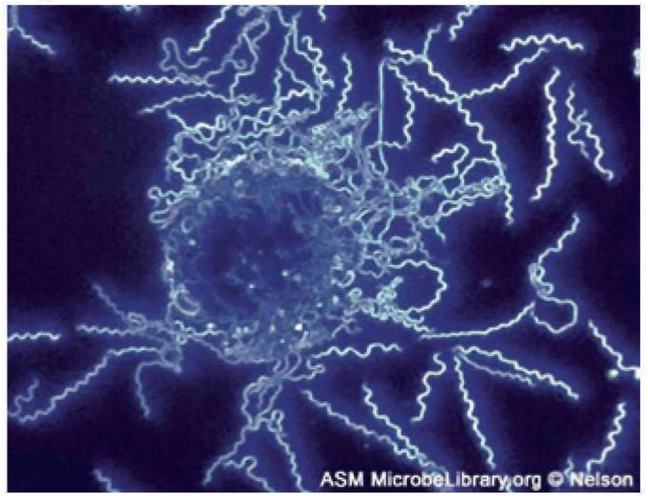
Thanks to their typical shape and motility, *Borrelia*e have always been delineated from other spirochetes and placed in a separate taxonomic branch. Twenty years ago, when Lyme disease was first described as a new clinical entity and *Borreliae* were discovered to be its etiological agent, great attention was paid to this spirochete. Over the years, a large number of *Borrelia* isolates have been provided from different human specimens, ticks and animal material. Requests for their full analysis were made. With the development of new microbiological, especially molecular methods, characterisation of *B. burgdorferi sensu lato* can now be provided in detail.

For a more systematic approach to *Borrelia* heterogeneity, a **serotyping system** has been developed. With a panel of monoclonal antibodies, *Borrelia*e were serotyped in relation to the antigenic characteristics of the OspA protein. At least seven different serotypes have been described. Later studies show a clear correlation between the particular OspA serotype and the species classification. The immunological diversity of the OspC protein, showing 13 different serotypes, appears to be significantly greater than that of OspA. Characterisation of *Borrelia* phenotypes is not so reliable, because *Borrelia*e may switch off the expression of a particular protein and change its protein profile and immunoreactivity.

Molecular typing based on the genetic characteristics of *B. burgdorferi sensu lato* can provide more precise information on the diversity of isolated strains. The *Borrelia* genome presents the main target for assessing the genetic relationships among the species, and a number of genotyping methods have been developed for identifying and differentiating particular strains.

Chromosomal DNA restriction profiles can be shown by pulsed-field gel electrophoresis (PFGE). It is a highly effective molecular typing method for *B. burgdorferi sensu lato* species identification. The *Borrelia* genomic DNA is separated by PFGE after digestion with a restriction enzyme, and the discrimination of strains is based on the large restriction fragment length polymorphism (RFLP) of the chromosomal DNA. *Borrelia* DNA is digested by numerous restriction enzymes to construct physical maps of the genomes and to define different groups of strains. *Mlu*I is a restriction enzyme with relatively few recognition sites and PFGE patterns after *Mlu*I digestion demonstrates specific bands for each species. In addition to species identification, *Mlu*I digestion shows genetic diversity and permits discrimination between strains within each *Borrelia* species.

Plasmid fingerprint. *B. burgdorferi sensu lato* strains have an unusual plasmid content of linear and circular plasmids that may vary in number and size. Only linear plasmids can be well separated by pulsed-field gel electrophoresis. The plasmid fingerprint is the best method of comparing and differentiating strains within the same species. The overall plasmid profiles might correlate with the particular species of *B. burgdorferi sensu lato* but definitive species-specific plasmids could not be identified.



Ribotyping is based on the profiles obtained by restriction fragment patterns of chromosomal DNA digested by appropriate restriction enzymes (*Eco*RI, *Eco*RV, *Pst*I, *Hind*III etc.) and hybridised with a probe derived from highly conserved rRNA. *Borrelia* strains can be distinguished by ribotyping at both species and subspecies levels.

Numerous **polymerase chain reaction** (PCR)-based methods are used for *Borrelia* genotyping. The main principle of any PCR is to get numerous copies of the target DNA sequence. An amplified DNA sequence can be separated by electrophoresis and stained with ethidium bromide.

PCR amplification with species-specific primers, either for chromosomal or plasmid genes, permits species identification directly. The most frequently used primer pairs for species-specific identification of *Borrelia* strains are those created for conserved 16S rRNA genes. Cross-amplification between species does not occur, even when a large input of template DNA is used.

Arbitrary primed PCR, also referred to as random amplified polymorphic DNA, allows PCR amplification of discrete sequences in genomes without any previous knowledge about them. Methods are based on the use of short random sequence primers that amplify different DNA segments of various bacteria species. Following separation by gel electrophoresis, PCR replicons demonstrate a pattern of bands which is characteristic for the particular bacterial strain. Randomly amplified polymorphic DNA analysis of *B. burgdorferi sensu lato* isolates is a reliable technique for identifying

From left to right: Brigita Repše, Milena Rici, Frančiška Čurila-Mikuž and Tina Šivic.
In the background: Urška Glinšek and Eva Ružić-Sabljić.

tion is tandemly repeated 23S - 5S rRNA genes. This specific organisation of the *Borrelia* genome, not present in other bacteria, is a suitable tool for species identification despite the lack of primer specificity. Digestion of amplicon with *Mse*I and *Dra*I enzymes results in different restriction fragments with species-differentiating characteristics.
In addition to digestion with restriction enzymes, PCR products can be analysed by DNA sequencing. PCR amplicons of 16S rRNA (*rrs*), *flagellin*, *OspA*, *OspC*, *p93*, *hsp60*, *p39* and other *B. burgdorferi sensu lato* genes have been sequenced and phylogenetic trees have been constructed from specific gene sequence analyses. Determination of the nucleotide sequence of multiple genes from numerous *Borrelia* strains is considered to be the gold standard for typing. The great advantage is a central database and the portability of sequence data. In 1997, the entire genome of *B. burgdorferi sensu stricto* strain B31 was reported.

Our results on Slovenian isolates

Lyme borreliosis is endemic to Slovenia. All major clinical manifestations of Lyme borreliosis have been found in Slovenian patients. The incidence of infection is among the highest in Europe. The first isolation of *Borrelia* strains from Slovenian patients was made in 1988. The great majority of Slovenian strains have been isolated from the skin of patients with early (erythema migrans) and chronic (acrodermatitis chronica atrophicans) infection, but also in patients with very rare (lymphocytoma, granuloma annulare) or nonspecific clinical manifestations, as well as from normal-looking skin at the site of a previous tick bite or previous skin disorder. Numerous isolates from cerebrospinal fluid have been isolated in patients with early and chronic infection of the central nervous system, but also in patients with skin manifestations without signs of central nervous system affection. *Borreliae* have also been isolated from the blood of Slovenian patients suffering from various clinical manifestations of Lyme borreliosis. In many cases, we have been able to confirm early dissemination of spirochetes and their presence in skin, blood or cerebrospinal fluid without any clinical or biochemical signs of their presence. Moreover, we have also reported on *Borrelia* persistence in skin and cerebrospinal fluid after appropriate antibiotic therapy, as well as re-infection in patients who have recovered from Lyme borreliosis, both confirmed by isolation.
We have set up a laboratory in our institute for *Borrelia* cultivation and identification, which is one of the very few centres to be involved in this kind of work and which has one of the best-know collection of *Borrelia* isolates.
The most frequently used method for *B. burgdorferi* sensu lato identification in our laboratory is a chromosomal DNA restriction profile followed by PFGE. Plasmid profiles are shown by PFGE, protein profiles by polyacrylamide gel electrophoresis. Identification of strains by different PCR methods has also been developed in our laboratory. The great majority of strains isolated from Slovenian patients have been identified as *B. afzelii* followed by *B. garinii*. *B. burgdorferi* sensu stricto strains are rarely isolated in our patients. The prevalence of particular *Borrelia* species depends on specimen origin: among skin and blood isolates *B. afzelii* is a widely prevalent species, while among isolates from cerebrospinal fluid, *B. garinii* is more frequently isolated. Although *B. burgdorferi sensu stricto* rarely causes infection in Slovenian patients, it has been isolated from skin as well as from cerebrospinal fluid of our patients. In several patients, isolated strains have not belonged to any of the three previously mentioned species, but are distinct new species. Some of these strains have been identified as *B. bissettii* and *B. spielamnii*, while other are still waiting to be identified.
Comparison of plasmid profiles is a very good tool for discrimination of strains within a species. In Slovenia, we have found numerous different plasmid profiles, suggesting great heterogeneity of strains in a relatively restricted area. We have also found unusual plasmid content, either plasmid dimer or multiple copies of large plasmid in nearly 13% of all Slovenian isolates.
Analysing the protein profiles of our strains, we have found a phenotypic heterogeneity that may affect pathogenesis, serological tests and vaccine development. We have found also a correlation between several Osp protein expressions and *Borrelia* species: *B. garinii* strains more often expressed the OspC protein than *B. afzelii* strains, while *B. afzelii* strains more often expressed OspB protein than *B. garinii*.

Tjaša Cerar, graduate microbiologist. Employed as young researcher in the Laboratory for microbiological diagnosis of borreliosis and leptospirosis.

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Research in the Field of Environmental Sciences at the University of Nova Gorica

By Polonca Trebše

Research at the University of Nova Gorica (formerly Nova Gorica Polytechnic) has been traditionally oriented towards environmental sciences. This is also evident from the fact that the Institution was founded in 1995 as the School of Environmental Sciences, where "environment" was always referred to from a very broad perspective. This is reflected in the activities of different research groups, which were established later as result of growth of the institution and which triggered the need for reorganisation and change of the institution's name. Research related to environmental sciences ranges from investigations at the molecular level to investigations of phenomena originating in the universe. Currently, environmental or environment-related research is conducted in four laboratories and two centres, which represent six out of seven research units at the University of Nova Gorica: the Laboratory for Environmental Research, the Laboratory for Astroparticle Physics, the Laboratory for Epitaxy and Nanostructures, the Laboratory for Multiphase Processes, the Centre for Atmospheric Research and the Centre for Environmental and Sports Physiology.

Assistant Professor Dr Polonca Trebše

In the first years after founding, our activity was primarily directed towards development of new analytical techniques and instrumentation for measurement of environmental parameters, and was very much dependent on collaboration and the availability of research equipment at other institutions, particularly the Jožef Stefan Institute; Wageningen University in the Netherlands; HASYLAB synchrotron radiation laboratories at DESY, Hamburg; ESRF in Grenoble; LURE in Orsay; ELETTRA in Trieste; and international collaborations such as DELPHI at CERN, Geneva, Switzerland; and the Pierre Auger Collaboration, where a substantial amount of our research was carried out. By attracting and employing many young scientists, graduate students and professors from all over Slovenia, we succeeded in building new research laboratories with state-of-the-art scientific equipment (gas chromatographs with FID, ECD and MS detectors, HPLC chromatograph with DAD and fluorescence detectors, ion chromatograph, fundamental and frequency doubled Ar lasers, excimer and pulsed dye lasers, LIDAR systems, atomic force microscope (AFM), simulation system for transport phenomena, etc.).

Junior researcher analyzing GC chromatograms (Photo P. Trebše).

At present, the major part of the environmental research at the University of Nova Gorica is conducted in the Laboratory for Environmental Research, where basic research activities are directed into different research fields. These include the development of laser-based methods, bioanalytical methods and ecotoxicological tests for identification and determination of toxic compounds and their effects on the environment, investigation of photochemical and microbial degradation, as well as the transport of pollutants in the environment, and the investigation of antioxidants in agricultural products, foodstuffs and biological systems. The activity of the laboratory has also recently extended into the preparation and characterisation of new materials which have potential applications in environmentally friendly systems, such as membranes for fuel cells and utilisation of alternative energy from biomass. Among our important research achievements, we must mention the development of highly sensitive analytical methods based on photothermal techniques, such as thermal lens spectrometry (TLS), which we combine with bioanalytical techniques (acetylcholinesterase – AChE biosensors), flow injection analysis (FIA) and liquid chromatography. Besides the detection of toxic compounds (organophosphate, carbamate and neonicotinoide pesticides, chromate, etc.), the methods developed are applied to investigate the role of biologically active compounds such as antioxidants in different physiological processes.

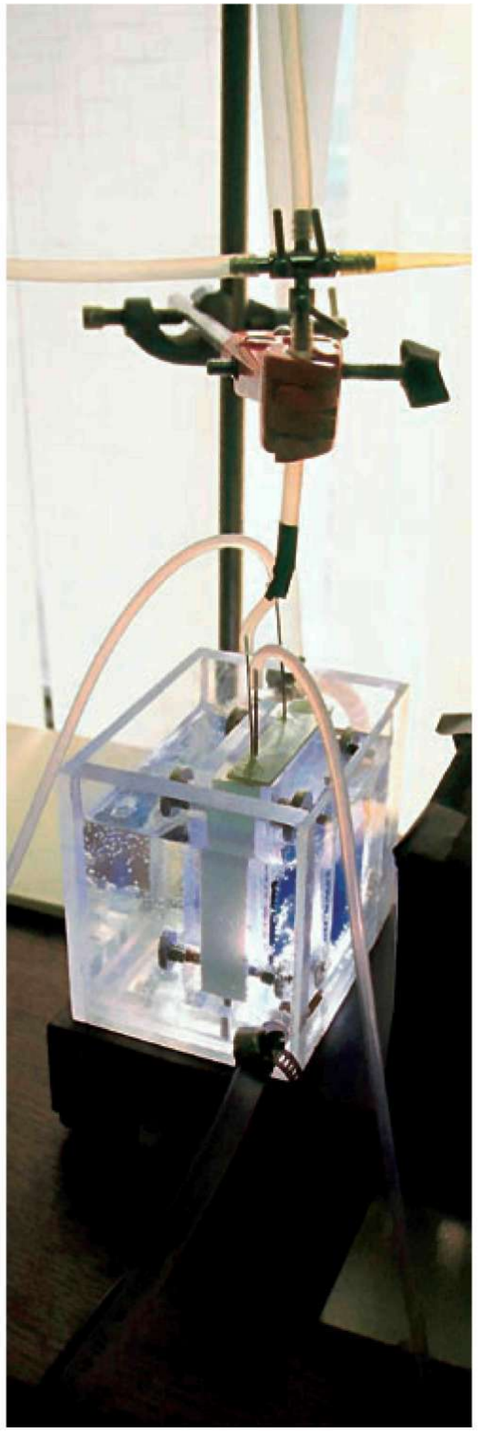
Fieldwork with students (Photo Jana Laganis).

Carotenoids are, for example, the subject of our investigations related to photochemical cycles in plankton and aquatic plants and phytoplankton cell lysis, while highly sensitive TLS detection of bilirubin is exploited to investigate the transport of antioxidants across cellular membranes and the function of associated transport proteins.

In the field of ecotoxicology we investigate the toxicity of organophosphorus and neonicotinoid pesticides. The effects of pesticides on terrestrial invertebrates (Isopoda) are studied based on activities of different enzymes, such as acetylcholinesterase and glutathion-S-transferase and energy reserves (lipids and glycogen) in organisms. In addition, changes in concentrations and the transformations of organophosphorous and neonicotinoid pesticides are monitored in the laboratory and in the natural environment during field experiments. The application of such organisms as indicators of environmental pollution is of major interest to us.

Because of their nutritional value, we investigate various groups of antioxidants such as anthocyanins and hydroxycinnamic acids in certain fruit species like sweet cherries and white grapes. We are primarily interested in the research of the local cultivars, and special attention is devoted to the impact of environmental factors on polyphenol content, such as growing position, weather and orchard or vineyard handling.

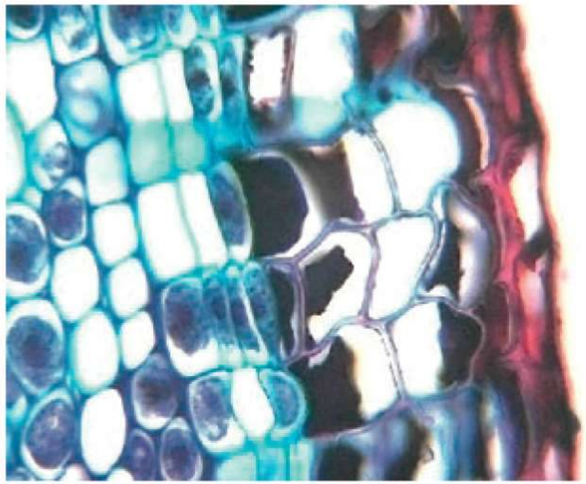
One of our latest interests is focused on the synthesis and use of TiO_2 thin films for environmental applications, which have already been tested in our laboratory for degradation of specific pollutants. We use a sol-gel technique for preparation of such films. By modifying the conditions of the sol-gel meth-



Photocatalytic cell (Photo U. Černigoj).

od and addition of a specific surfactant and by high calcination temperature, we are able to change the morphology and structure of the films. In addition, we are working on thin films prepared in a low-temperature sol-gel process, which is more suitable for substrates like plastics. For the determination of the structure of thin films, different spectroscopic and microscopic techniques are applied. For example, the surface roughness of nanostructured TiO_2 films is characterised by atomic force microscopy, an invaluable tool for characterisation of nano materials. The atomic force microscope is the latest achievement of the Laboratory for Epitaxy and Nanostructures, where it is mainly employed to assess the morphology of single-molecular-layer organic semiconductors, which are fabricated in the Laboratory by organic molecular deposition using an ultra-high vacuum evaporation chamber. In addition, the nanoscale electronic properties of organic semiconductor thin-film transistors are investigated using a conductive atomic force microscope and a Kelvin probe.

Relevant results were recently achieved in the area of photocatalysis,



Cork formation (Photo Jana Laganis).

where our experiments are focused on the application of TiO_2 thin films as the catalyst for degradation of substituted phenols, textile and other dyes, pesticides and pharmaceuticals under simulated (UV light) and environmental conditions. New techniques for degradation of pollutants, such as pharmaceuticals, pesticides and endocrine disruptors in waste and drinking waters by laser light, ionising radiation and advanced oxidation techniques (i.e. ozone) are being investigated as well.

In our endeavours toward the development of novel, sensitive and selective methods of chemical analysis, we exploit the advantages of the latest laser technology (for example, intra-cavity frequency doubled Ar-ion laser) and laser-based methods such as thermal lens spectrometry. By combining TLS and HPLC liquid chromatography, we have developed a highly sensitive method for determination of neonicotinoid pesticides (thiacloprid, imidacloprid, thiametoxam and acetamiprid), which

Virgin forest at Rajhenavski Rog – field work in ecology (Photo Jana Laganis).

Endangered and protected crab species (*Macropodia longirostris*) (Photo Jana Laganis).

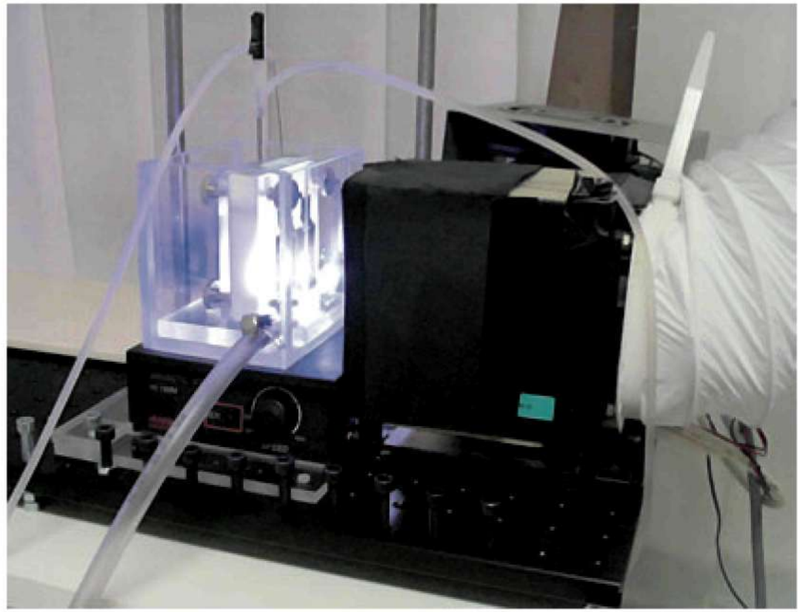
enables their quantification at concentration levels as low as 10 ng/mL, as demonstrated for thiacloprid. This is one order of magnitude lower compared to spectrometric diode array detection in HPLC.

Among other approaches to enhanced sensitivity of photothermal methods, we also use ionic liquids, which belong to the group of "green solvents". On one hand, this is important because it reduces emissions of volatile organic compounds into the environment, but, on the other, as we have demonstrated by performing the first measurements of the thermooptical properties of ionic liquids (thermal conductivity, temperature coefficient of refractive index), they also provide a favourable medium for photothermal measurements, which offers up to 25 times the sensitivity of TLS detection in aqueous solutions.

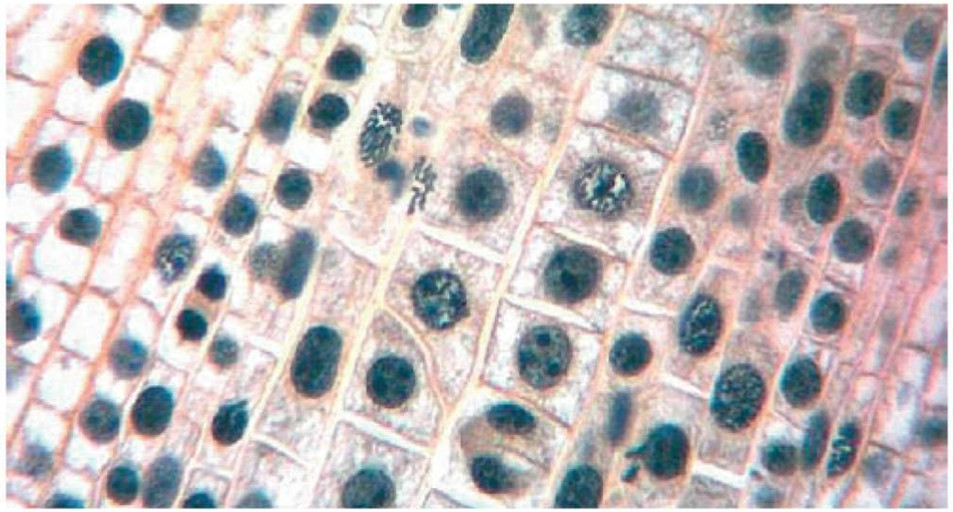
The most recent application which demonstrates the importance of highly sensitive analytical methods is the investigation of the transport of bilirubin, an important endogenous antioxidant, across the cellular membrane of hepatic cells and the role of transport proteins in the cellular membrane. By applying TLS we achieved an LOD of 1 nM bilirubin and enabled measurement of its uptake by HepG2 cells under normal physiological conditions, where the maximum concentration of bilirubin is limited to 50 nM by its low solubility. This concentration is inaccessible by conventional spectrometric methods. In collaboration with Prof. Sabina Passamonti's group from the University of Trieste, we have demonstrated that the uptake of bilirubin is significantly increased by the presence of lactate and ethanol, which reduce the $NAD^+/NADH$ concentration ratio in hepatic cells and trigger the transformation of billitranslocase into its high-affinity conformation. The role of the membrane protein bilitranslocase in the transport mechanism of bilirubin was studied by measuring the uptake of bilirubin in hepatic cells in the presence of substrates of other organic anion transporting proteins, such as digoxin. This had no effect on the uptake of bilirubin, and for the first time experimentally confirmed the role of bilitranslocase in the transoport of bilirubin across the cellular membrane.

Our activities in the field of applied research are oriented primarily towards the application of photothermal and bioanalytical techniques for food quality control. In this regard, newly developed analytical methods are applied to determine characteristic carotenoids which serve as indicators of the quality and origin of olive and other vegetable oils, and fruit juices. AChE-based photothermal biosensors are presently being tested for large-scale application in fruit juice production, where they will be used as a rapid and low-cost screening method for the presence of organophosphate pesticides.

We have recently initiated several studies on the ecological energetic properties of terrestrial ecosystems. This reflects the so-called systems ecology approach to the evaluation of sustainable management, where estimation of ecosystem integrity is the most important. The central interests of our activities in this field are studies of ecosystem growth and development processes, and self-organizing properties of ecosystem evolution. We apply modern techniques ranging from thermal remote sensing of ecosystem surfaces to estimation of the information stored in genome size. Special attention is paid to nonlinear thermodynamic parameters as systems indicators (e.g. specific exergy, exergy dissipation, inclusive Kullback index and



TiO_2 films irradiated by UV light, thus promoting the degradation of organic matter in water (Photo U. Černigoj).



Mitosis in the root apex of Allium (Photo Jana Laganis).

emergy). Relationships between these indicators and ecosystem growth and development processes are evaluated with different ecological modelling tools, including STELLA, EcoPath, etc.

New approaches are also being exploited in investigations of the pollution of soil with heavy metals. In this regard we examined several urban areas in south England (Cornwall), where the soil is contaminated with an extremely high level of arsenic (up to 15%) as a result of the historical mining, processing and refinement of arsenic ores in purpose-built calciners. The results showed that arsenic is mostly associated with amorphous phases or adsorbed species, which represents high environmental risk and implies a potential leaching of arsenic into drinking water sources or uptake by locally grown crops and which consequently poses a danger to the public. Assessment of the chemical form of arsenic and its speciation was crucial in this case. For this reason EXAFS (Extended X-ray Absorption Fine Structure) and XANES (X-ray Absorption Near Edge Structure) x-ray absorption methods for analysis of the atomic and molecular structure of sampled soil were exploited. EXAFS is often the only practical way to study the arrangement of atoms in materials without long-range order. Traditional diffraction techniques cannot be used in such cases, and EXAFS is therefore a powerful tool in the non-destructive analysis of environmental samples. The results of this research are expected to initiate the development of effective remediation strategies and management of such highly polluted sites. A development of a similar environmental assessment methodology for lead-contaminated land around a former lead mine in the Meža Valley in Slovenia is in progress. We are examining the capacity of humic acids, the natural carbon-rich biopolymer constituent of soil, to interact with cyano-complexes and thus affect the leaching of complexes and prevent the consequent risk of contamination of the water table. We showed that interaction between humic acids and ferricyanide complex led to formation of ferricyanide-humo micelles, and that the interaction did not imply changes in the original structure of the ferricyanide complex.

For remote sensing of air pollution and physical processes in the atmosphere, we use the most recent laser technology. Our first steps in the field of remote sensing were, however, triggered by the need to control the quality of the atmosphere when we investigated high-energy cosmic rays as part of the Pierre Auger Collaboration in which the Laboratory of Astroparticle Physics is involved. As a result, the first aerosol LIDAR in Slovenia was assembled. The instrument enables measurement of relative concentrations of aerosols and the absorptivity of the atmosphere at 355 nm at distances up to 25 km and with a spatial resolution of 10 m and temporal resolution of 3 seconds. Such an instrument, which is computer-controlled from Nova Gorica, has been installed at the Pierre Auger Observatory for high-energy cosmic rays in Malargue (Argentina) – the largest observatory for cosmic ray research ever built. Our second LIDAR system has been assembled at Otlica near Ajdovščina where the Centre for Atmospheric Research is engaged in studies of aerosol transport in the higher troposphere. In collaboration with the University of Iowa, methods are being developed for indirect determination of emission rates, wind profile and vertical diffusivity of aerosols around highways, streets and other sources of pollution. The development of a mobile lidar for studies of air pollution transport in the atmospheric boundary layer is also under way.

The University of Nova Gorica is successfully working together with the Slovenian Agency for Radwaste Management (ARAO) and other regulatory bodies on a computer simulation of the foreseen Slovenian low and intermediate nuclear waste repository. Simultaneously, the enhancement of our own simulation capabilities for the assessment of the transport of radionuclides and other pollutants in different natural and technological systems is in progress. The simulation tools are based on the most advanced meshless numerical techniques, developed in the Laboratory for Multiphase Processes. These methods are also used in simulation systems for the steel and aluminium industries, and brick production, where the quality of the product and minimal environmental impact of the process are of great importance.

Our applied research in this field has resulted in an intense collaboration with the aluminium company Impol in Slovenska Bistrica for simulation of temperatures, velocities and concentrations in DC cast aluminium alloy billets and slabs. The collaboration is reflected in improved regulation algorithms and substantial enhancement of product quality and process yield. The computer-aided automatic optimisation of process parameters in the continuous casting of steel, related to domestic, Czech and Finnish steelworks, is underway within the European Concerted Research Action, designated as COST-526. A project on modelling hollow-brick manufacturing and usage was started for the Goriške Opekarne brickworks. All related industrial process modifications and upgrades are performed in close cooperation with industrial research teams.

Sponge crab (*Dromia personata*) (Photo Jana Laganis).

Interest in health-related environmental issues has recently been extended to research projects at the Centre for Environmental and Sports Physiology. In the field of environmental physiology our research is focused primarily on human performance in normoxic and hypoxic environments, and takes into account both cardiovascular and respiratory systems. We have also been investigating the effects of particulate pollution on the respiratory functioning of asthma patients and "voluntary" dehydration levels occurring during exercise in warm environments. These projects involve research partners with different scientific backgrounds, from physiology, medicine, sport science, physiotherapy, etc. The field of environmental physiology enables us to focus on physiological responses in humans with respect to the different environmental factors which in one way or another affect the performance of our physiological systems.

The laboratories at the University of Nova Gorica are also part of the technological platforms Advanced Materials and Water and are active partners in EU co-financed national centres of excellence including the *Centre of Excellence in Environmental Technologies*, where we collaborate in the project Biological Treatment of Waste Waters with the work package Photochemical Degradation of Pesticides, *Centre for Advanced Processing, Technologies and Materials*, which includes development of new, environmentally friendly technologies in production of technologically important ceramic materials and the *Centre of Excellence in Nanoscience and Nanotechnology*, where we collaborate in the project *Nanostructured Surfaces and Interfaces*.

Through the subalpine beech forest (Photo Jana Laganis).

Fieldwork in ecology (Photo Jana Laganis).

I am grateful to my co-workers at the University of Nova Gorica who contributed to this paper:

**Prof Dr Mladen Franko,
Prof Dr Gvido Bratina,
Prof Dr Iztok Arčon,
Prof Dr Božidar Šarler,
Asst Prof Dr Darko Veberic,
Asst Prof Dr Klemen Bergant,
Dr Petra Golja, research associate.**

INSECTS: From Behaviour to Physiology and Biodiversity

Andrej Čokl and Meta Virant-Doberlet

Professor Dr Andrej Čokl

Dr Meta Virant-Doberlet

Life on Earth depends on insects, which are present in almost all habitats: in the air, water and on land. The number of insect species is unknown, but several million is probably the most realistic estimate. Insects were the first animals to colonize Pacific islands following nuclear weapons experiments; plant reproduction and fruit production depend on pollination by insects; they destroy at least one third of all the food produced by humans; insects are important elements in food chains; and finally, insects are the vectors for many serious human, animal and plant diseases. Research into insect life is the subject of entomology, one of the central branches of biology.

The great diversity of insect species, their rapid reproduction, the incredible variety of mechanisms which they have evolved for coping with challenges in their environment, and rapidly expanding knowledge as a result of new technologies are key reasons for the specializations of different groups of entomologists. Basic research on insect life provides opportunities for fast and direct application in agriculture, medicine, environmental protection and the development of new technologies based on the biological mechanisms which insects have evolved. Heightened public attention and expectations of obtaining straightforward answers to questions crucial for everyday life compel specialized groups in the field to co-operate intensively in order to exchange knowledge, technology and information. The Department of Entomology at the National Institute of Biology comprises a group of researchers whose investigations of insect behaviour, communication and neurobiology are recognized internationally.

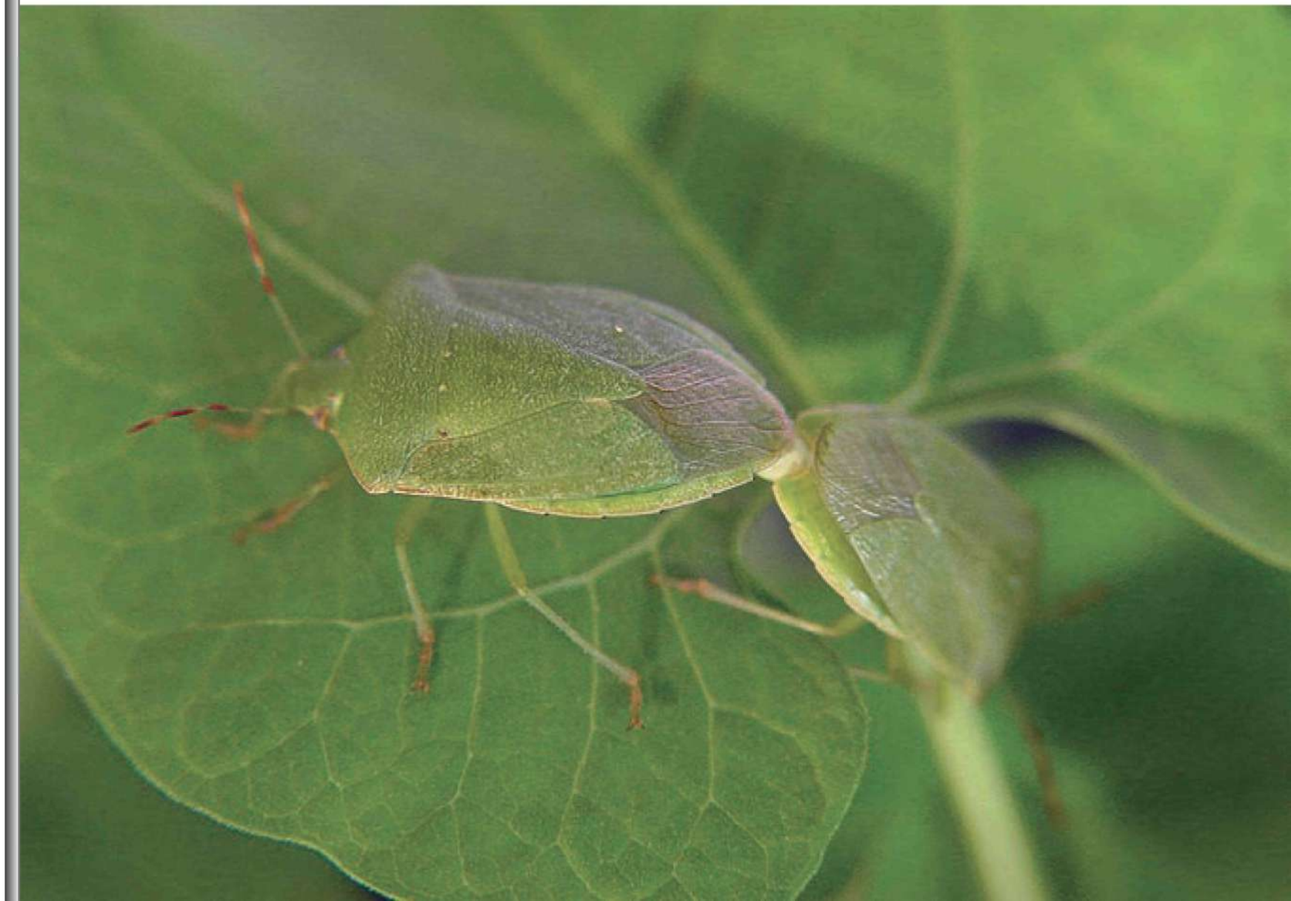
Proximate and ultimate levels of analysis of behaviour offer an opportunity to discriminate between mechanistic and evolutionary explanations. The proximate level is focused on genetic-developmental and sensory-motor mechanisms, while ultimate causes focus on the historical pathways leading to behaviours and on the past effects of natural selection in shaping current behaviour. On this theoretical basis the research programme of the Department of Entomology is directed towards different topics regarding communication processes in insects. Communication plays a central role in animal societies, and the study of signals identifies the types and amounts of information animals convey to each other. The results of animal communication research can be used as tools for the elucidation of general evolutionary principles and, finally, they provide ideas for various practical applications.

The research programme at the Department of Entomology is concerned mainly with vibrational communication, which is prevalent in insects within species, families or phylogenetic distributions. Communication may be defined most simply as the exchange of information between a transmitter and a receiver by signals transmitted via various media.

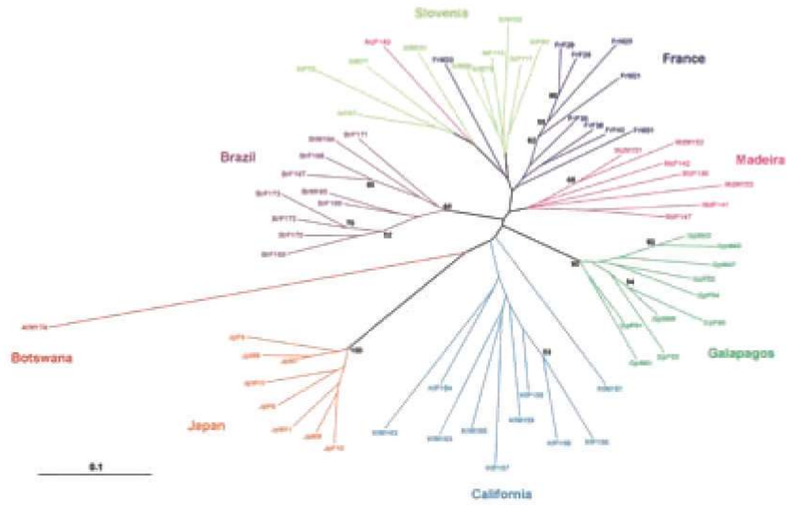
The biophysical properties of the medium (air, water or land) change the quality of the signals transmitted. The transmitter and receiver have to communicate with signals which preserve the information despite its transformation during transmission. The study of the biophysical properties of transmission media assists us in understanding the evolution of signal production and reception structures. Plants are the most common substrates for vibrational communication in insects, and the study of their mechanical properties is at the centre of scientific interest of the group. Low-intensity signals emitted by different insects are recorded by laser vibrometers in different plant segments and at different distances from their sources; changes in their temporal and spectral characteristics are correlated to obtain explanations about the information which enables an insect to respond to basic problems such as where to go to meet a mate, who is calling, warning or courting, how far away they are, whether the transmitter is a threat, whether the insect has entered another's territory, etc. Knowledge obtained through basic research constitutes the scientific background of applied projects in which researchers in the group, along with colleagues from the University of Ljubljana, apply laser technology to monitor the presence of wood-boring insects in religious and artistic objects, and in testing the resonant properties of the differently treated woods used to make musical instruments.

Signals used for communication are species-specific; they enable discreteness and thus isolate species and prevent hybridization. Although species are rarely recognized and identified by direct studies of reproductive behaviour, this is actually the ultimate determinant for biological species. The vibratory signals emitted by different species are recorded and systematically investigated relative to their temporal and spectral characteristics. Comparative studies enable an understanding of the languages and dialects of different animal groups. These studies are upgraded by investigations of the informational value of various signal parameters for the recognition and localization of sources. The outcome of long-term research is the scientific basis for the optimization of biological control techniques such as pheromone traps, which attract mates by species-specific signals. The latter are useful taxonomic tools for the recognition of species in environments where individuals cannot be accessed. The study of signals has accelerated due to the necessity of enhanced research of biodiversity, the geographical origins of invasive species, and of plant-insect interactions in the context of global warming. The recent results of the Department of Entomology on the diversity of signals between eight geographically separated populations of the globally invasive pest species *Nezara viridula*, together with molecular analyses, have demonstrated among other things that the species originates in Africa and has revealed African, Japanese (Asian) and divergent European-American lineages. A significant positive correlation between geographical isolation and genetic divergence on the one hand, and on the other, no correlation between either geographical or genetic distance and differentiation of populations by song, indicates that evolution has enforced a stable structure for the information carried by vibratory signals.

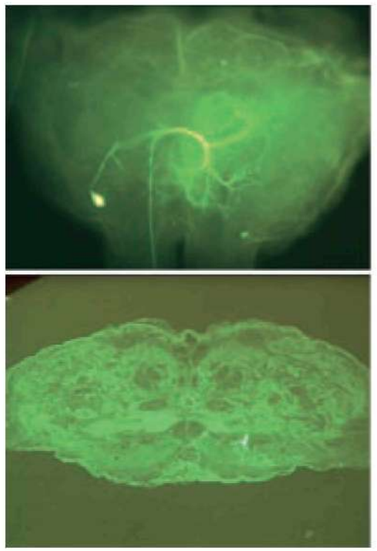
The anatomy and function of receptor organs and the underlying sensory element of the neuronal system pathway depend significantly on signal modality and on the influence of the medium on transmitted signal amplitude, time and frequency characteristics. New methods developed for anatomical and morphological studies demand re-investigation of sensory organs in order to clarify in detail the role of supporting structures in signal transduction, and to

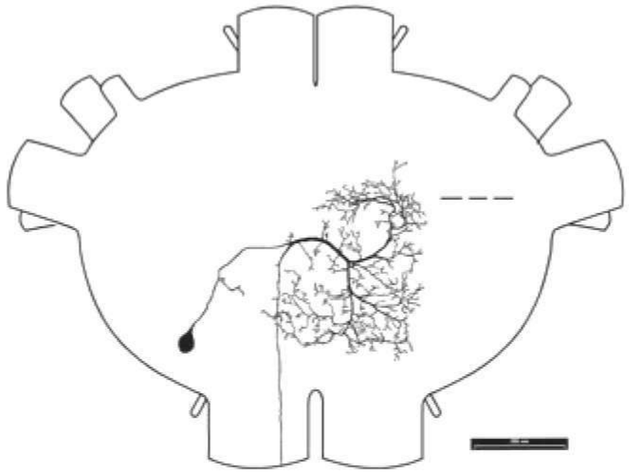


Southern green stink bug *Nezara viridula*. (Photo by Meta Virant-Doberlet)



Neighbour-joining tree based on individual RAPD (Random Amplified Polymorphic DNA) profiles of 66 *Nezara viridula* specimens sampled from eight allopatric locations. Bootstrap values (1,000 replications) above 50% are given at the nodes. (From: Petra Pavlovčič, PhD Thesis, University of Ljubljana, 2005).





The morphology of a vibration-sensitive interneuron located in the prothoracic ganglion of the cave cricket *Troglophilus neglectus* (plan view, scale 200 μm). The neuron responds to the vibrations of the front legs of the animal. An image of a transverse section of the preparation is taken at the level indicated by a dashed line. (Courtesy of Nataša Stritih).

understand the process of the transformation of mechanical to electrical energy at the receptor membrane. The experimentally confirmed relevance of various signal parameters enables the study of the functional properties of specific neuronal networks at the single cell level. The intracellular recording of electrical activity of stimulated nerve cells and their simultaneous staining with highly selective dyes provide an opportunity to study connectivity within the network together with input/output relations. Neurobiological investigations of invertebrates are important as model studies for understanding the functioning of the central nervous system in vertebrates when the most powerful insect model open up opportunities for investigation of movement control and its development at the single cell and molecular genetic levels.

Bees constitute one of the most popular insect species and have various beneficial impacts on human life. In recent decades bee-keeping has faced various ethical or technical reasons do not allow a direct experimental approach. The comparative neuroanatomy and neurophysiology of specific neuronal networks help in our understanding of the evolution of the central nervous system as the basis for any behaviour.

An important step forward has been taken with the investigation of ontogenetic development in fruit flies which began recently with the transfer of knowledge and technology from Queensland University in Brisbane (Australia) to the laboratories of the Department of Entomology. Under optical control, an identified neuronal cell in a living embryo is destroyed by a laser beam and the specific behavioural pattern during ontogenetic development of the specimen is monitored. Since the history of the destroyed part of the central nervous system is known, one can determine the neuronal basis of the ontogenetic development of the behaviour pattern under investigation.

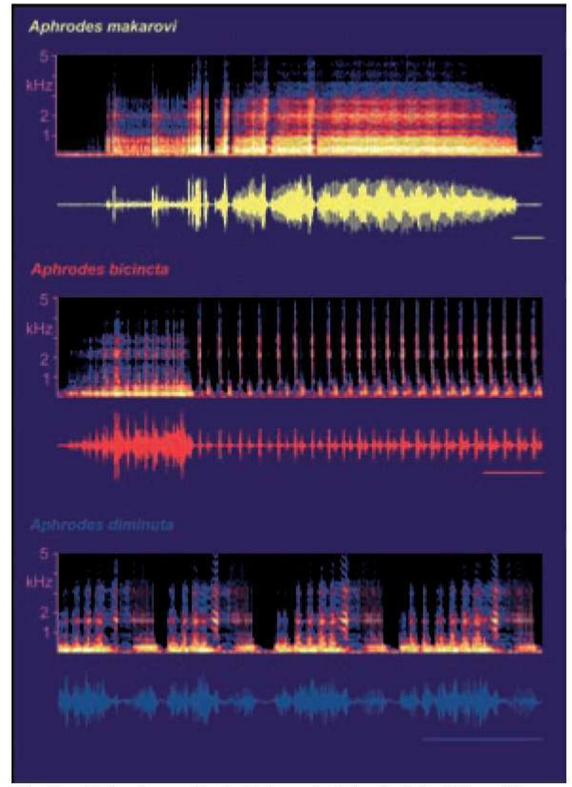
Studies of the ontogenetic development of symmetrical posture and the role of sensory neurons in fruit flies as

problems which have endangered it worldwide. The use of the insecticide imidacloprid in the last decade was probably the most serious problem to have divided the scientific community, although many other questions deserve attention. To reinforce investigations on bees in Slovenia the Department of Entomology began studying the influence of diseases on behaviour and the immune response of foraging bees (*Apis mellifera).* This project has connected the Department with outstanding research institutions in this field in Germany.

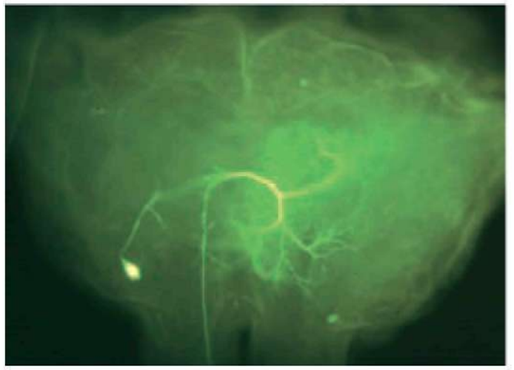
With several million species, insects have evolved such a wide variety of responses and adaptations that any group of entomologists must restrict itself to only a limited number of groups or species. Thus it is important to have close connections with other groups in order to incorporate knowledge within a broader framework. The animals used in research in the Department of Entomology are those which are economically important: pollinators, such as bees and bumblebees; pests, such as stink bugs, leafhoppers and plant hoppers; species studied as models for adaptations to specific environmental pressures, such as cave crickets; invasive species; and insects which are used as models in neurobiology or genetic research, such as cockroaches and fruit flies.

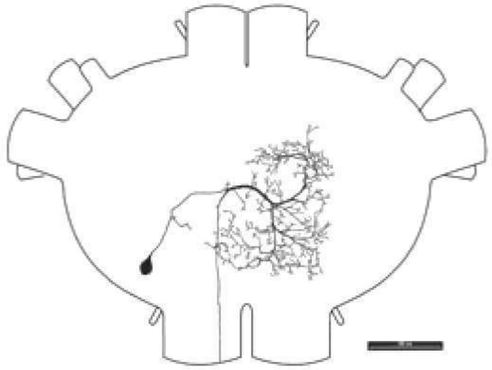
In the last ten years the Department of Entomology has collaborated on various projects in Slovenia, mainly with the Agricultural Institute of Slovenia and the Biotechnical Faculty of the University of Ljubljana. There has been international collaboration on different kinds of projects, including the EU's 6th Framework Programme. Our main international partners are Karl-Franzens University of Graz (Austria); University of Pisa (Italy); University of Würzburg (Germany); University of Göttingen (Germany); Aristotel University of Thessaloniki (Greece); INRA Versailles (France); University of Madeira (Portugal); University of Sussex (UK); Cardiff University, Wales (UK); The National Museums & Galleries of Wales, Cardiff (UK); University of California, Riverside (USA); EMBRAPA (Brazil); Chinese Academy of Science, Beijing (China); and Queensland University, Brisbane (Australia). Scientists in the group are involved in education at various levels at the University of Ljubljana and Nova Gorica Polytechnic.

The results of the group's scientific work have been presented in articles published in the leading scientific journals in the field, such as *The Annual Review of Entomology, Journal of Experimental Biology, Physiological Entomology* and *Journal of Comparative Physiology*. Researchers in the group are also members of the editorial boards of esteemed international journals. In 2006 two chapters published by Taylor & Francis in the book *Insect Sounds and Communication: Physiology, Behaviour, Ecology, and Evolution*' reviewed part of the scientific output of the group. The group's work has been presented in the BBC TV series *Talking with Animals*, and reviewed in *New Scientist* and the BBC's *Wildlife* magazine. Researchers at the Department of Entomology are members of the Entomological Society of America, the Royal Society of Entomology, London, and the Entomological Society of Brazil.



Vibrational signals are the best characteristics for identifying different species of the leafhopper genus *Aphrodes*. Sonograms (above) and oscillograms (below) of the male call songs for three species are shown. Scale bars indicate 1s.





The morphology of a vibration-sensitive interneuron located in the prothoracic ganglion of the cave cricket Troglophilus neglectus (plan view, scale 200 μm). The neuron responds to the vibrations of the front legs of the animal.

Laboratory for Inorganic Chemistry and Technology,
National Institute of Chemistry, Ljubljana

Inorganic Materials

Research and Application

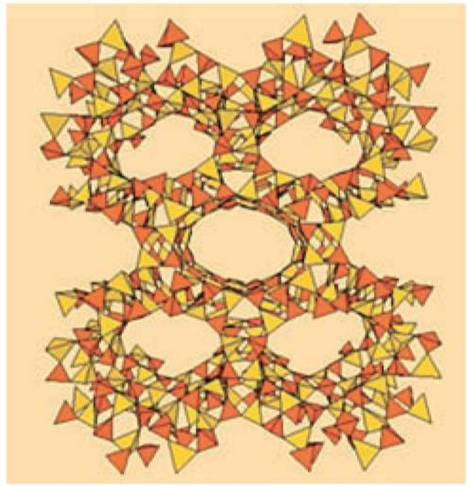
By Alenka Ristić, Nataša Zabukovec Logar, Nataša Novak Tušar, Gregor Mali, Roman Gabrovšek and Venčeslav Kaučič

Introduction

The remarkable success of microporous inorganic materials such as zeolites has been due to their great applicability in many industrial and research areas. Today nearly everybody comes in contact with zeolites, since they have almost completely replaced polyphosphates in softening water for washing purposes. Some natural or synthetic zeolites are used for the removal of heavy metal ions and ammonia from waste and drinking water, because they are selective, radiation and thermally stable, and show a high cation exchange capacity. Zeolites are also commercially applied for air-purification and separation purposes due to their great sorption properties. They can specifically remove indoor pollutants like formaldehyde, chloroform and ammonia. In oil refining, which is commercially the most important application of these materials, zeolite catalysts are used in order to obtain maximum conversion of crude oil residue after distillation to fuel with specific properties. Around 300,000 tons of synthetic zeolites are used annually in catalytic (for petrochemical processes, especially the fluid catalytic cracking process) and adsorptive applications. A further 300,000 tons of natural zeolites per annum are used in the construction materials and paper industries, in waste water treatment, in soil improvement, as an animal feed additive and as cat litter.

The common feature of zeolites and zeolite-like materials such as aluminophosphates, gallophosphates, titanosilicates and certain other phosphate-based or silica-based microporous materials is a three-dimensional, low-density, and open-framework structure. The latter consists of AlO_4, PO_4, SiO_4 or other metal-oxygen tetrahedra (MO_4), linked to each other through bridging oxygen atoms. Due to well-defined channel and cavity systems with pore dimensions up to 15Å, zeolite-like materials are able to recognise and discriminate molecules with a precision of less than 1Å and can act as sieves for molecules. The importance of these materials has increased recently due to their activity as hosts to a range of other species, including small clusters of semiconductors, coordination complexes or metal clusters for optical and electronic applications. Chiral framework structures are potentially useful also for enantioselective separation and catalysis. There is currently a growing demand for zeolite-like molecular sieves with larger pore size and retained high shape selectivity, as well as well-defined and isolated active sites for catalytic conversions of larger molecules and for the separation of more complex mixtures. Considerable attention is now being concentrated on silica- and phosphate-based mesoporous materials with 20-100A pore sizes and their use in adsorption and catalysis.

Staff of the Laboratory for Inorganic Chemistry and Technology (from left to right):
Edi Kranjc, technician
Dr Nataša Novak Tušar
Professor Dr Venceslav Kaucic, Head of the laboratory
Dr Nataša Zabukovec Logar
Matjaž Mazaj, PhD student
Saša Cecowski, PhD student
Dr Alenka Ristic
Dr Gregor Mali
Olga Gorše, technician
Mojca Opresnik, technician.



Schematic presentation of a large pore microporous gallophosphate ULM-5 with a chemical composition of $Ga_{16}(PO_4)_{14}(HPO_4)_2(OH)_2F_7$. A three-dimensional network in which gallium atoms are four-, five- and also six-coordinated (yellow polyhedra) and phosphorous atoms four-coordinated (orange tetrahedra) contains 16-, 8- and 6-member ring channels, whose free aperture is up to 12.20 × 8.34Å.

In response to these challenges, our group is intensively focused on the design and synthesis of new porous materials with new or improved properties for industrial applications. The head of the group of the Laboratory for Inorganic Chemistry and Technology is Prof Dr Venčeslav Kaučič. Twelve individuals are currently employed, of whom seven are researchers, two are PhD students and three are technical staff. Their expertise in characterisation methods such as X-ray powder diffraction (XRD), solid-state nuclear magnetic resonance (NMR) spectroscopy, thermal analysis, particle size sedimentation, density and BET surface area determination have frequently been requested in the last ten years for basic and applied research.

Basic research

The group focuses on the synthesis and structure characterisation of metal-modified nanoporous materials with silicate- and phosphate-based frameworks. Special emphasis is given to the structure determination of products and spectroscopic investigation of catalytically active sites (Bronsted-Lewis and redox) present in the frameworks as a result of incorporation of the transition metals (Me = Co, Zn, Mn, etc.). Our hydrothermal syntheses are based on the use of template molecules as structure directing agents, which incorporate in the structure pore during the synthesis and are subsequently removed by thermal treatment to obtain a porous material. There are many parameters that affect the synthesis of new products during gel preparation and crystallisation, including the type and solubility of the starting components, the mixing, the ageing and pH of the gel, as well as the temperature and pressure during crystallisation of the material. All these parameters have to be very carefully adjusted in order to prepare materials with particular pore geometry.

New as-synthesised materials have to be structurally characterised in order to elucidate their functions and determine their uses. We currently use powder/single-crystal X-ray diffraction (XRD) techniques for the determination of framework topologies. For the determination of fine structural features like the nature and position of catalytically active metal sites, and the location, orientation and disorder of templates, metals or complexes within the microporous hosts, which has long been an almost insoluble problem, in addition to X-ray diffraction methods, we use other characterisations such as some newly developed Nuclear Magnetic Resonance (NMR) methods, UV-Visible (UV-VIS) absorption and infra-red (IR) spectroscopy, elemental analysis (EDX), as well as X-ray absorption methods, especially the anomalous dispersion method and EXAFS/XANES (Extended X-ray Absorption Fine Structure / X-ray Absorption Near Edge Structure) in connection with the use of synchrotron radiation sources and advanced computer techniques. We are also applying in-situ X-ray methods for studies of the phase transitions during template removal or moisture absorption.

Complementary scientific research with the Jožef Stefan Institute in Ljubljana and University of Nova Gorica in Nova Gorica (EXAFS/XANES) and the Faculty of Chemistry and Chemi-

Preparation of a reaction mixture for hydrothermal synthesis.

Complementarity of x-ray powder diffraction and solid state NMR

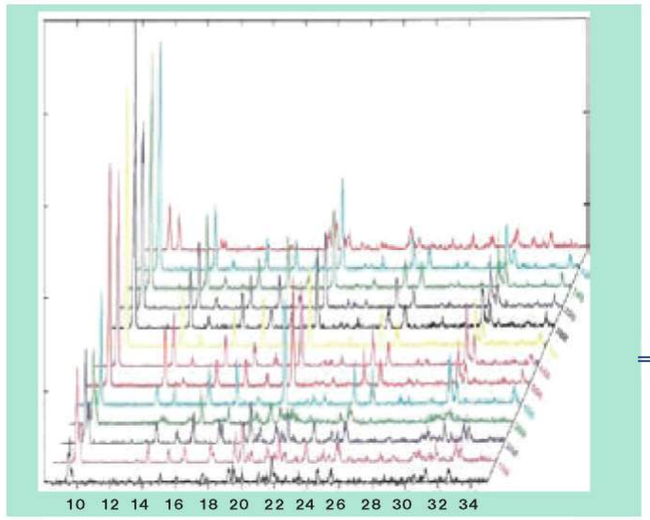


Figure 1: XRPD patterns of triclinic form of $AlPO_4$-34 (chabazite topology) during thermal treatment in air. The first pattern was measured at room temperature (RT) before thermal treatment, while the last one was measured at room temperature after thermal treatment (red).

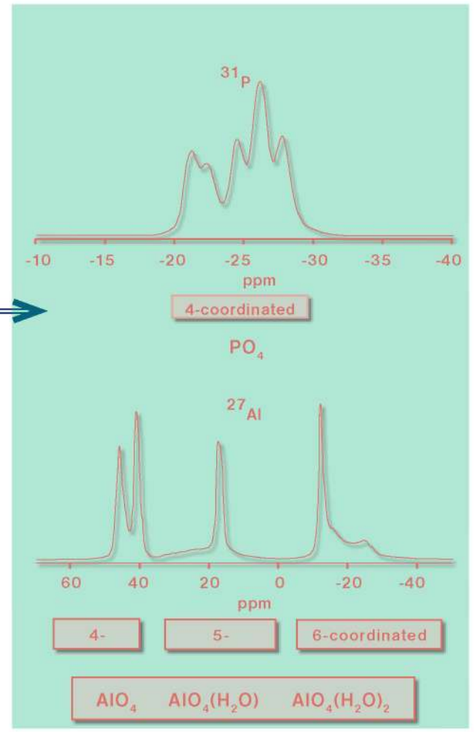


Figure 2: ^{31}P and ^{27}Al MAS spectra of the sample (last XRPD pattern) after thermal treatment.

New instrument in the laboratory: X-ray powder high resolution diffractometer X'PertPRO MPD.

The triclinic form of $AlPO_4$-34 (RT - 300°C) adopts a rhombohedral symmetry upon heating (400–700°C) and cooling (700–50°C) (Fig. 1). This structure distorts in the presence of moisture from air, resulting in a new triclinic deformation of the chabazite framework. The new phase is a consequence of the ability of framework aluminum atoms to modify their coordination in the presence of water molecules (Fig. 2). The structure was elucidated by combining high-resolution synchrotron powder diffraction with solid-state NMR techniques.

cal Technology in Ljubljana enable us to characterise our products with synchrotron radiation. The last-named institution has also been very helpful with information from UV-VIS spectroscopy and single crystal XRD. International collaborations with the universities of Belgrade (synthesis and characterisation of zeolite-like materials), Manchester (single crystal XRD, anomalous dispersion), Versailles (solid-state NMR) and Vienna (crystallography, spectroscopy), and also with scientific institutions such as Institute Rudjer Bošković Zagreb (mechanism of zeolite synthesis), ETH Zurich (crystallography), UMIST Manchester (Atomic Force Spectroscopy – AFM), ISMRA-CNRS Caen (in-situ IR, catalysis), University Pierre et Marie Curie Paris (catalytic tests on zeolite-like materials), benefit from exchange of knowledge, joint projects and publications, postgraduate students and postdoctoral research.

X-ray powder diffractometry

The application of X-ray powder diffractometry:

- determination of the degree of crystalinity,
- qualitative phase analysis (use of standards),
- quantitative phase analysis,
- determination of particle sizes and micro-tensions,
- indexing and determination of symmetry,
- structural analysis.

We are equipped with:

- X-ray powder diffractometer Siemens D 5000 (radiation wavelength CuK = 1.5406) for measurements of powder patterns with high resolution at high temperatures from 50 to 1450 °C, at low temperatures from the boiling point of liquid nitrogen to 400°C in a vacuum or other atmospheres and for measurements of thin films.
- X-ray powder diffractometer PANalytical X'Pert PRO (radiation wavelength CuK = 1.5406 A) for measurements of powder patterns in four different configurations: (1) alpha1 with Johansson monochromator, for flat samples; (2) capillary transmission with Hybrid monochromators (3) standard Bragg-Brentano; and (4) parallel beam.

SDT 2960 thermal analysis system

Thermal analysis

The SDT 2960 Thermal Analysis System (DSC-TGA / DTA-TGA, TA Instruments, Inc., New Castle, DE, USA) simultaneously measures heat flow and weight changes associated with transitions and reactions in materials from ambient temperature to 1500°C. The information obtained differentiates endothermic and exothermic events which have no associated weight changes (e.g. melting or crystallization) from those which involve a weight change (e.g. degradation). It can be used to obtain both qualitative and quantitative data, including:

- boiling points,
- melting points,
- liquid crystal transitions,
- heats of transition and reaction,
- heat capacity,
- oxidative and thermal stability,
- purity,
- polymer curing,
- glass transitions,
- reaction kinetics.

Compliance with Good Laboratory Practice (GLP) is facilitated in UA-2000 because full details and actual calibration data are saved with each Data File.

Applied research

Co-operation between our laboratory and SALONIT Anhovo takes the form of a long-term research programme. The subject of co-operation is research into the hydration of special geothermal cements and studies on blended cements containing calcium carbonate and various mineral admixtures. Blended cement is a ternary system Portland cement – puzzolan-X, with X denoting blast furnace slag, fly ash or silica fume. The research is focused on the study of physical and chemical properties developed during the course of the hydration process, with particular emphasis on phase composition, microstructure characteristics, bending and compressive strength, porosity and sulphate resistance. The final goal is the formulation of an optimal composition of blended cement that meets all the requirements of present, and yet to be implemented, standards. The co-operation with SALONIT has proved mutually very successful in coming very close to the essential goals, plans and problems that were postulated at the beginning of the co-operation.

Our laboratory has been also intensively collaborating with SILKEM d.o.o. (Kidričevo) for a long time in different applied projects, such as investigation of the influence of CO_2 on dry water glass (expert evaluation), the development of a procedure and technology for production of layered and precipitated silicates, investigations of liquid and crystalline silicates, granulation of

Professor Dr Venčeslav Kaučič, Head of the laboratory.

silicates, the development of a process for the production of layered silicates. We have recently been working on the development of synthesis and an industrial process for the production of Zeolite X as a builder (water softener) for detergents. The components of most modern detergents are surfactants, builders, bleaching agents and special additives such as enzymes. Surfactants remove dirt from textile fibres, but their effectiveness depends on a certain degree of hard water. An important role of zeolites is to soften the water (binding of calcium and magnesium ions through ion exchange) and thus to ensure the effectiveness of the surfactants. Zeolite X was hydrothermally synthesized in our laboratory from hydrogels prepared from aqueous solutions of sodium aluminate and water glass. Products with a good exchange capacity, chemical composition and proper size of crystals were prepared. An industrial application is in progress.

There are also many other formal or informal contacts established with research groups from pharmaceutical companies, like Krka and Lek, and other companies like Polident from Volčja Draga, Color from Medvode, for analytical services and also some common research projects. Several new postgraduate studies have arisen during the co-operation with industry and resulted in MSc and PhD theses by young researchers from the companies.

Solid-state nuclear magnetic resonance

Nuclear magnetic resonance (NMR) is a powerful tool which yields information about the local structure and dynamics of solid and liquid samples. Our group specialises in measurements in powdered samples, such as molecular sieves and cements, and performs most of our NMR experiments at the National NMR Centre at the National Institute of Chemistry. For solid -state measurements the centre is equipped with several magic-angle sample spinning probes for 300 MHz and 600 MHz Varian Unity Inova spectrometers. This equipment enables us to perform all of the major modern, high-resolution solid-state NMR techniques:

- Magic-angle sample spinning (MAS) spectra supply information about the neighbourhood of the observed nuclei and is the basic technique for obtaining high-resolution spectra of polycrystalline samples.
- Cross-polarisation (CP) enhances the sensitivity of measurements (enables observation of rare 13C nuclei) and is indispensable in magnetic resonance of organic and inorganic materials.
- Multiple quantum magic-angle spinning (MQMAS) technique is designed for the study of half-integer quadrupolar nuclei such as 23Na and 27Al and also provides high-resolution spectra.
- Several new techniques for measuring internuclear distances and identification of chemical bonds.

Instruments for powder characterisation

- Tristar 3000, an automated gas adsorption analyser (Micromeritics Instrument Corp.) for specific surface area (BET) measurements, adsorption isotherms, volume pore and pore size distribution of powder samples (mesopores and macropores: > 2 nm).
- Microtrac S3500 Particle Size Analyzer, wet or dry samples. The range of measurement for wet samples is from 0.02 µm to 1400 µm (2800 µm) and for dry samples from 0.25 µm to 1400 µm.
- AutoPycnometer (Micromeritics Instrument Corp.) for automatic determination of true density of materials with helium.

BEER IN PET PACKAGING

By Lilijana Peklar

Beer in PET bottles has been challenging the entire European beer-brewing industry as well as allied (co-dependent) industries. Until recently, this packaging used to exist more in theory than in practice; however, due to faster progress PET packaging has become more and more attractive for use with oxidation-sensitive beverages (different juices, wine, beer, etc.).

On extremely competitive markets where beers do not only battle other beer trademarks but also many other alcoholic beverages (i.e. beer blends, various alcopops, wine, etc.), the differentiation and recognition of packaging is also of great importance. Obviously, PET has great potential. Market competition became even stronger after Slovenia entered the EU, and beer in PET packaging on our market was only a question of time.

Pivovarna Laško, d.d. launched 0.38 l PET packaging in 2004 as the result of years-long research and testing of suitable materials. At the beginning of 2005, the initial PET packaging was followed by the introduction of 0.5 l and 1.0 l PET multilayer packaging due to low market interest for the 0.38 l capacity. In view of previous market activity, the Slovene market was found to be completely comparable to the traditional Western market, where this kind of packaging has gradually been making inroads – the share of beer in PET packaging is practically negligible at present, however.

Lilijana Peklar

Brief History, Business Strategy of the Company, Production Figures, Assortment

By Matej Oset, Head of the Technical Department

Pivovarna Laško, d.d. has taken the leading position in the Slovene beer-brewing industry, with more than one hundred seventy-five years of tradition, and there are three important time periods in its history to be pointed out. In 1825, Geyer, a seller of honey and sweetmeats, rearranged his Laško workshop into a brewery employing ten workers. Therefore, almost a century and a half later, the most profitable, respectable and promising economic activity of the town was established. In 1938 the Laško Brewery became a joint-stock company set up by Slovene innkeepers, thus reviving beer brewing after the factory had been closed down by a German competitor. Fifty employees were given jobs in those days.

In 1995, the Laško Brewery would become a joint-stock company entered in the court register of Celje, and thus the Brewery, having the major share of the Slovene market, passed into the hands of 14,500 shareholders.

Pivovarna Laško, d.d. has constantly been keeping abreast of advanced world standards and has been directing its available capital to the most up-to-date technologies in order to make its beer quality competitive with the world's top brewers, based strongly on its traditional and proven recipes, kept as well-guarded secrets by the company.

Pivovarna Laško, d.d. devotes permanent investments to technology in order to meet the highest level of quality demanded by its customers, and provides employment for 340 workers. In 2005 Pivovarna Laško, d.d. sold 841,474 hectolitres of beer on the Slovene market and 240,234 hl on foreign markets. In 2005 the parent company, as well as the whole Laško Group, ran an extremely successfully business, dramatically surpassing the company's results in 2004 – history will record 2005 as one of the most significant to the enterprise.

In 2000, Pivovarna Laško, d.d. became a 94.55% owner of Jadranska Pivovara in Split and assumed 88.4% ownership in Radenska, d.d., in Radenci (which grew to 92,06% in 2006). The company had previously acquired a 51% ownership share in Vital d.o.o., Mestinje in 1999, which grew to 95.53% in 2006.

Without doubt, the year 2000 signifies one of the most important turning points in the history of the enterprise as the result of the capital interlock with Radenska, d.d., Radenci; Jadranska Pivovara, d.d., Split; and Vital, d.d., Mestinje. At the same time, the turn of the millennium also witnessed the launch of the enterprise's new business development strategy involving capital interlocking with the above companies.

In 2002 the enterprise managed to take over Pivovarna Union, d.d., Ljubljana with a 47.86% share of all company stock in a tender offer. However, Pivovarna Laško continued its capital investment by acquiring a 24.98% share in Delo, d.d., Ljubljana and thus became the leading owner of the company. In December 2004 Pivovarna Laško managed to acquire an additional 27,011 shares of the Union Ljubljana joint-stock company, which signified a 5.98% ownership. In this way, the Pivovarna Laško, d.d. joint-stock company became a 53.85% owner of all Union stock.

In February 2005 Pivovarna Laško, d.d. bought out the entire Interbrew ownership share, i.e. 186,400 shares of the Pivovarna Union, d.d., Ljubljana share issuer and thus became a 95.17% owner of that company. Now the share is 96,73%.

In 2006, the business strategy of the enterprise will focus on gaining new markets in the European Union as well as in Southeast Europe, where the marketing approach will be introduced to reinforce its efforts to offer premium quality products and trademarks using the LAŠKO PIVO crown to create the basis for uniform brand identity in all markets.

Pivovarna Laško Group, selling more than 5 million hectolitres of beverages, is becoming the most powerful beverage manufacturer in Southeast Europe. The brewery will continue its policy of strategic interlocking and globalisation to expand the economies of scale, purchasing power and capital and competitive advantages to aim at becoming the largest beverage manufacturer and supplier in Southeast Europe.

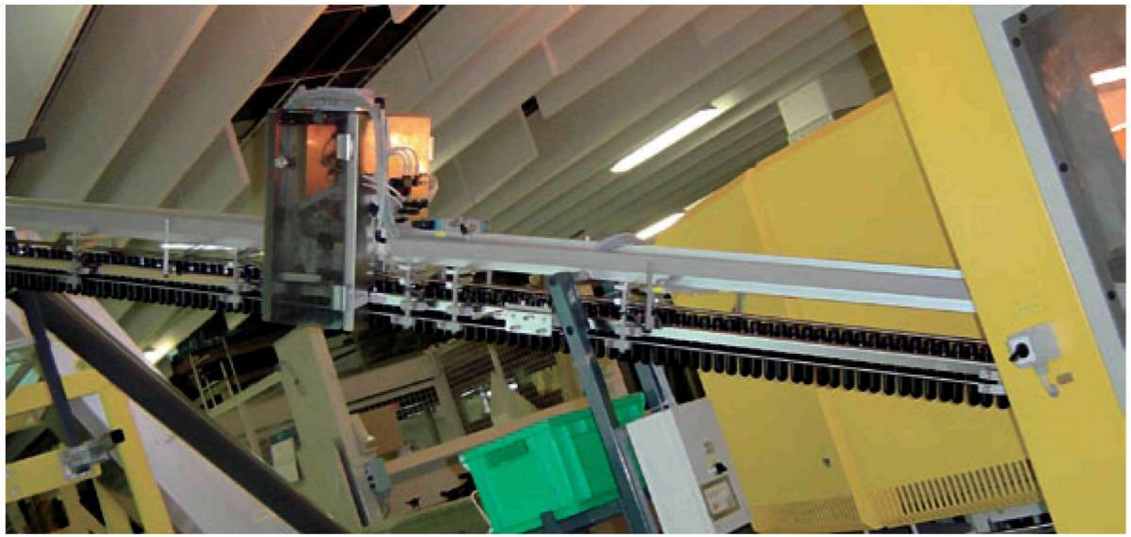
The production programme of Pivovarna Laško, d.d. involves beer products ranging from Gren light beer (1.7% vol), Laško Lahko light beer (2.7% vol), Zlatorog and Laško Club (4.9% vol) to Laško Temno dark beer (5.9% vol). Also included are special pale beer with the refreshing taste of tequila and lemon – Bandidos Tequila (5.1% vol), pale beer with Caipirinha aroma – Bandidos Ice (4.0% vol), a blend of pale beer and lemonade – Bandidos Light Lemon (2.4% vol) and spring water – Oda. In 2004, Pivovarna Laško, d.d. introduced a new variety of beer packaging – PET plastic bottles.

PET material

Polyethylene terephthalate (PET) is a very important polymer material used for packaging food products. Since the '70s when it was first introduced as a packaging material, its use has risen significantly. In fact, it is mostly involved in the beverage industry (more than 80% of all PET use) instead of traditional packaging previously dominated by glass and metal. It has also been replacing other plastic packaging materials, such as polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC). The material itself became attractive in the field of non-returnable packaging mostly as the result of its properties and reasonable price.
PET is a linear, thermoplastic polyester produced by the esterification reaction of glycol and terephthalic acid. The combination of the aromatic component, which derives from terephthalic acid, and the aliphatic component of glycol determines the specific properties of the material. Copolymerization with other monomers produces resins of different degrees of crystallinity, including amorphous material. Polymer strength, durability, bonding power, gas permeability and thermal stability are consequences of crystal structure. However, the specific extension, ability of retracing to an elementary state, toughness, clarity and diffusion depend on amorphous areas in the polymer. In practice, the PET characteristics of specific extension depend on its molecular mass, tensile ratio, level of crystallisation, humidity, temperature and kind of copolymer and its structure.
Not only do properties as the outcome of polymerisation have a huge effect on PET material, but there are also various additives that are incorporated during the process of extrusion and moulding of a plastic resin or applied externally on the formed material. These substances are added in order to achieve suitable processing and the ultimate properties of the material (antioxidants, UV stabilizers, softeners, colorants, dyes, fillers, antistatics, etc.).

Advantages and disadvantages of PET packaging

Typical PET plastic bottles usually weigh only 24 to 40 g (0.5l), which represents only one-tenth of the weight of comparable glass packaging. They are also fracture or smash resistant (appropriate for picnic use, concerts, sports and other outdoor events where traditional glass packaging involves safety risks). With screw caps, the bottles can be reclosed and their transparency makes the content visible (a "clear" advantage over aluminium – beer cans); good flexibility of colour and a variety of PET bottle designs are also made possible. Furthermore, these bottles can be accurately manufactured and, like glass, the material is completely recyclable.
The biggest PET packaging disadvantage is its permeability to gases. In order to achieve the minimum expected shelf life of beer, i.e. six (6) months, it is of great significance to assure PET material resistance to oxygen uptake and loss of carbon dioxide. It is true that no material is 100% impermeable to gases. Carbon dioxide plays a characteristic role in beer – it is responsible for its fresh taste and affects the beer's stability and sharpness; its content in beer ranges from 3.5 to 5.5 g/l normally and it can be characterized as having good solubility, which it holds as the temperature rises, but the pressure in the packaging rises as well. The loss of carbon dioxide during storage depends on the packaging material. PET does allow a high degree of CO_2 permeability from the bottle as the consequence of partial pressure; oxygen penetration into the plastic bottle is quite possible. Oxygen is found to be approximately 40-times less soluble in beverages than carbon dioxide. It may enter the beverage during the process of filling and storage. For this reason, we have to make the right decision about the material which the bottles are made from; the bottling process itself is also very significant and should enable as little oxygen penetration during the process as possible – and even the appropriate material from which the bottle closures are made should be taken into account. Oxygen dissolved in beer responds in different ways according to different ingredients, which causes organoleptic modification, thus lessening the shelf life of beer drastically. During the process of bottling under pressure and use of CO_2 as the supplanting gas, the oxygen value should not exceed 0.1 mg/l.
Beside the material of the plastic bottles and closures, and the system of bottling and storage, it is also the size of the plastic bottles that affects gas migration. The ratio between the volume and surface of bottles favours larger bottles – the permeability effect is lower. Oxygen migration should not exceed 1.0 mg/l over a period of six months; on the other hand, the loss of carbon dioxide is not expected to be higher than 15%.



With reference to the above facts, we can claim that the development of new materials has been focused on the implementation of PET barrier characteristics lately because the standard PET plastic bottles without additives are only suitable for bottling less oxygen-sensitive beverages, such as water, lemonade and cola drinks. For oxygen-sensitive beverages, including beer, it is very important to reduce the permeability of the material, which can be achieved in several different ways, of which the following three methods are important: barrier masses, coating and multilayer technologies.

Method of barrier masses

This method is based on the principle of passive barriers that can retard gas permeability through the material. They can be used like monomaterial with added PET (blends) or can act like a special layer in multilayer plastic bottles. PEN has been considered the most effective monomaterial (polyethylene naphthalate) because of its more favourable barrier characteristics than pure PET (up to five times less oxygen and carbon dioxide permeability) – it is more durable when exposed to high temperatures, although it has not been commercially successful due to its high cost (up to three times more expensive). PET/PEN copolymers are more common in practice.

PET plastic bottles with barrier coatings (monolayer plastic bottles)

Coating methods can be divided into two categories: first, the methods which involve vacuum or plasma routes to deposit extremely thin films of organic (ethylene vinyl alcohol – EVOH, polyvinylidene chloride – PVDC, epoxy amines, polyamides – nylon) or inorganic material (amorphous carbon or glass silicon dioxide) as passive barriers on the inner or outer

surface of a blown plastic bottle; and second, methods which are based on the atomised spraying of liquid organic materials onto the external surfaces of the plastic bottle (this method has not been commercially accepted). In the beverage industry, the method of inner plasma coating involving inorganic materials has been most popular. Both carbon and silicon dioxide allow good barrier protection against oxygen and carbon dioxide, and since they are applied to the inner surface of plastic bottles, they do prevent the oxygen dissolved in the PET matrix from migrating into the beverages (beer) within the first several weeks of storage.

Multilayer technologies

In order to improve PET packaging permeability characteristics, the use of multilayer technology has already proved itself a perfect alternative. A particular material is used as an independent layer in a multilayer structure, i.e. a sandwich method where the inner layer is enclosed by additional layers of some other material (PET and other polymers) – up to seven-layer plastic bottles have already been introduced (three-layer plastic bottles have been used in beer bottling). These layers come together as manufacturing preforms for plastic bottles and play a role in protection against gas permeability. Such materials based on EVOH, PA and PEN were found to be good passive barriers, proving themselves to afford protection from the loss of carbon dioxide from beverages, but less effective against oxygen penetration. For this reason, different manufacturers developed the combination of inner chemically active and outer passive (physical) barriers. The function of the inner active barrier is to absorb oxygen that penetrates through the plastic bottle before it reaches the end product (e.g. beer) – together with the already present oxygen in the headspace of the plastic bottle and the oxygen which is in the end product itself, the total oxygen content is reduced. These materials are given the common name "oxygen scavenger". In fact, they all are polymers that are not stabilized against oxidation and that start to decompose when they are in contact with air. Therefore, it is very important to have a good passive barrier which allows as little oxygen as possible to enter the bottle, depending on time, temperature and relative humidity of the storage environment. Along with a rise in temperature, oxygen permeability rises too, thus the scavenger material is used up more rapidly. The combination of good passive protection and at least 1% active protection is the best solution.

Besides the previously mentioned problems with gas permeability through the material, another disadvantage of plastic bottles is their inability to be heated (pasteurisation difficulties) as the result of deformation caused by high temperature and thus physical instability. Preevacuation with CO_2 is not possible either, to the same degree as with glass packaging, which may lead to higher initial oxygen values. In comparison with glass, plastic bottles have lower solidity. For this reason, closing the plastic bottles causes problems as well.

Bottle closures

In addition to making the right decision about the material which plastic bottles are made from, the same importance holds true for closure material and type, since all components are a significant factor in oxygen intrusion and, consequently, self-life. At the moment, there are different possibilities being offered on the market, such as plastic (HDPE or LDPE) screw closers or aluminium ones, crown corks and so-called ring-pull closures, all having both good and bad aspects. The main advantage of the most commonly used plastic screw closures is the possibility of reclosing the bottle; however, the average one-piece screw cap is highly gas permeable. A two-piece cap has a separate insert or liner to improve the seal on the neck of the bottle. For oxygen-sensitive beverages (beer), the liner can also be made from a gas barrier material or an oxygen scavenger material (or both) to remove oxygen from the bottle headspace and improve the barrier performance of the cap. Similar characteristics also obtain with aluminium screw caps (they always require a liner); however aluminium caps may damage the plastic bottle when closing it.

Crown corks are the most widespread form of glass packaging closure, owing to good price and low gas permeability; however, they cannot be used to close plastic bottles since the high pressure involved in the capping head might damage the bottle. Reclosing is not possible either. On the other hand, ring-pull scavenger caps have been recognised as extremely attractive, as they require lower capping power than corks and no damage to plastic bottle necks have been reported. Unfortunately, they are not reclosable and may injure the user (cuts). Thus, it is more or less up dependent on consumer requirements which type of closure should be used and, of course, to our own packaging possibilities.

PET filling systems

Modern technology has made PET filling quite a simple procedure, with high bottling velocity and only a small group of employees required. At Pivovarna Laško, d.d. the filling capacity of the line is 12,000 plastic bottles per hour with only five line operators. The line capacity is more or less determined by the capacity of the stretch blow-moulding unit. From this step on, the plastic bottles are transported by air transport to the filling unit. In our company, a safer method of filling has been used, which involves rinsing the plastic beer bottles in a rinser unit. In order to avoid undesired oxygen intrusion, the rinsing is carried out with degassed water.

Filling PET packaging can be performed in various ways: by fixed volume, fixed weight or a required level inside the plastic bottle. The first and last systems have come into use mostly, but both have their advantages and disadvantages. Volume filling enables precise filling and is more appropriate for plastic bottles of large diameter, in which 1 to 2 mm of level difference can mean higher losses. This system of filling has been well used in filling cans.

Since plastic bottles have not been physically stable enough to permit preevacuation with CO_2 and, consequently the reduction of oxygen in the plastic bottle, the method of rinsing with CO_2 under atmospheric conditions has become more common with beer filling in PET packaging. The classic system of level filling involving short tubes, which is used with glass packaging, enables low oxygen values including additional rinsing with carbon dioxide. In the case of double preevacuation of 0.5 l glass bottles, about 260 g CO_2/hl of beer is used, while in case of the average filling system involving short tubes and no preevacuation, as much as 3000 g CO_2/hl of bottled beer is used in filling 0.5 l plastic bottles. As the result of the large CO_2 consumption, it was necessary to develop new filling systems. One such system is level filling with long tubes and this has already been implemented at Pivovarna Laško, d.d. In fact, the system is based on filling from the bottom to the top of the plastic bottle without preevacuation. We are able to achieve extremely low values of charged oxygen (from 0.02 to 0.03 mg/l), and the use of rinsing CO_2 is lower than in the classic system (up to 700 g CO_2/hl of beer).

Testing procedures in Pivovarna Laško,d.d.

In our company, initial tests were carried out with various monolayer blend materials. Tests were performed by comparing these bottles with bottles made from 100% PET without any additives as the least inert packaging and glass packaging as the packaging with the lowest gas permeability. Ring-pull scavenger caps were use on the samples, except on the glass samples, where common crown corks were used. For all samples we used the same beer type and rank. The particular ratios between materials turned out to act as an extremely sufficient gas barrier, but some specific reactions between the layers (barriers) has occurred, which affected the final stage of beer sensority drastically. However, only an expert would be able to notice any modification of the characteristics of pale beer when the content of oxygen exceeds 1 mg/l.

When repeating the testing procedures we focused mainly on the plastic bottles. Taking into account all PET packaging and the beer characteristics listed, we decided on multilayer plastic bottles produced by a recognized manufacturer with an integrated active layer and equipped with plastic scavenger closures (active layer made of sodium sulphite) as the subject of our further testing. Filling conditions and beer characteristics were kept unmodified. With the use of these materials we managed to achieve more than a six-month shelf life. No significant organoleptic modifications of the beer were detected during this time.

Conclusion

A major step in PET packaging development has been taken lately in order to meet beverage company and consumer expectations. Both segments require as long a shelf-life as possible, in which the main role is played by the stability of the organoleptic properties of the beverages as the result of decision-making about the appropriate plastic bottles and closure material as well as the proper system of filling. Now it is the consumer's turn to decide on the suitability of beer in plastic bottles and, of course, both price and tradition will be important factors in this decision.

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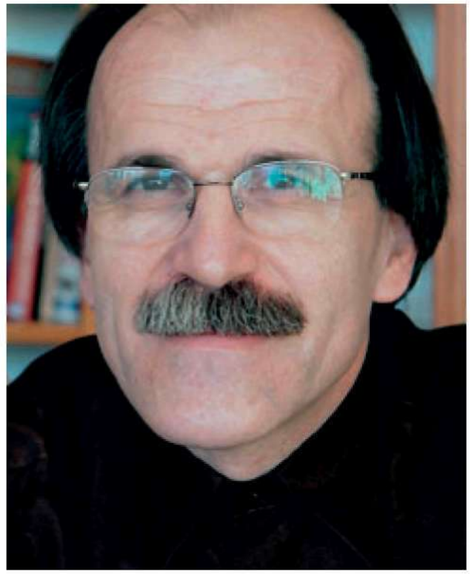
Overlays on Bridge Decks
Made From High-Performance Fibre-Reinforced Concrete

By Jakob Šušteršič

Introduction

Waterproofing membranes on bridge decks represent a persistent problem, especially on bridges with heavy loads and on bridge decks with sharp inclines. In the case of asphalt overlays, waterproofing membranes are subject to frequent damage, which results in costly repairs. On the other hand, a damaged membrane can cause premature deterioration of the bridge deck and other elements. The necessity to construct new bridges, as well as to repair existing ones, can be lessened if the waterproofing membranes are properly placed in optimal weather conditions; otherwise, the quality of the membranes will be poor. In such cases premature repair will be necessary, thus increasing the cost of construction and maintenance of the bridges.

Therefore, new materials for waterproofing membranes have been developed along with the application of new design concepts to bridge decks, where double concrete courses are used, with the upper course made from high-performance concrete. Our solution to this problem came from the idea that the upper course should be much thinner than the lower one. As an overlay of the deck, it has to take on two fundamental functions: protection from water penetration and resistance to abrasion. Besides these two functions, it has to furnish a bearing capacity compatible with the loading of the bridge deck. These characteristics will be fulfilled as long as the water-tightness, soundness and resistance to crack propagation of the overlay concrete is achieved. High-performance fibre-reinforced concrete (HP FRC) has the above-mentioned properties.



Dr Jakob Šušteršič, General Manager of IRMA.

The required properties of HP FRC were studied in a development project that started in 1996. Investigations of HP FRC specimens were carried out in the laboratory as well as in pre-construction tests. Three applications were realised in the project, which was financed by Slovenian Government – Ministry of Transport and several industrial concerns. The two main goals of the project were: first, correlation between the overlay and its performance under loads, which needs to be considered over the lifespan of the bridge; and second, accumulation of useful results for future reference and experience in the design and construction of overlays of bridge decks made from HP FRC, especially for future highway construction projects.

Different varieties of high-performance concrete and their properties

High-performance concrete belongs to the category of concrete with special properties, that is, differing from normal concrete in at least one important property. Due to their low w/c (w/c < 0.40) and different modifications to the composition (polymers, fibres, additives), they have high strength and achieve a high level of durability, i.e. service life. With the addition of effective plasticizers (such as a high-range, water-reducing admixture – HRWRA), it has become possible to greatly reduce the w/c ratio and achieve, regardless of the modest cement content, good workability. With superplasticizers based on polynaphthalene and polymelamine, it is possible today to produce concrete with a w/c ratio ≤ 0.30. The new generation of superplasticizers based on sulphonated vinyl co-polymers provide evidence of additional technological improvements of concrete. Advanced superplasticizers (ADSP) are also being developed. One such ADSP is based on polycarboxylate, which contains the cross-linked polymer, SP-A. A combination of polymer dispersions and superplasticizers are also in use.

Well-compacted concrete with low w/c ratios achieve a high strength and are thus termed high-strength concrete. Concrete with a compressive strength above 150 MPa is called ultra-high-strength concrete. But by increasing the strength of the concrete, brittleness also increases, which can be reduced by adding fibres, polymers, or both.

By lowering the w/c ratio and adding polymers, concrete of very high-quality structure can be formulated if the correct technological procedure is applied. Such concrete can display a high level of durability, which is proven by the results of a number of tests and research work.

Workability is increased by adding latex to concrete with Portland cement, because of the "ball-bearing" effect of the polymer particles and the closed air pores, and the dispersion effect of the surfactants in the latex. With constant workability, the w/c ratio decreases, contributing to the higher strength and lower shrinkage of the hardened concrete.

The higher the strength of the concrete, the more brittle its response. From the stress-strain curve of concrete with different strengths, it can be seen that the higher the compressive strength, the steeper the slope of the descending part of the curve. If the slope of the descending part is vertical, this should mean that the behaviour of the material is similar to that of classic brittle materials, such as glass. Of course, concrete is not as brittle as glass or as ductile as steel. That is why fracture mechanical methods, which have been developed for glass and steel, cannot be directly applied to concrete.

Sufficient quantities of latex will increase the ultimate strain capacity, ductility and toughness of concrete with Portland cement. This improvement is

IRMA Institute for Research in Materials and Applications

By Andrej Zajc

The activities of the IRMA institute include research, development, testing, consulting and engineering. The Institute specializes in concrete, concrete technology and concrete products, with research and development primarily in the field of cement and polymer-bonded composite materials. The majority of the composite materials used today are specialized high-performance concretes. The Institute also devotes its attention to the questions of recycling harmless industrial and building waste materials.

In consulting and engineering, the Institute provides technical support and solutions to complex problems in concrete technology. It also provides technical supervision and quality control of materials. Of special interrest in this field is the use of the most advanced materials and solutions in the repair and restoration of concrete structures. In this area, scientists at the Institute initially determine the condition of the structure, particularly determining the causes of any damage; they then design the repair procedure as well as provide technical supervision of the most complex stages.

The IRMA testing laboratory performs tests on concrete, aggregates, mortars, concrete products, masonry units, and various products and systems for the protection and repair of concrete structures, accredited according to the SIST EN ISO/IEC 17025:2002 standard and deriving from the laboratory's accreditation certificate No. LP-008 of 7 March 2005 from the Slovenian Accreditation (SA) institute.

Dr Andrej Zajc

IRMA is a certification body for factory production control of concrete production according to SIST EN 206-1:2003 and SIST 1026:2004 standards and a notified body for certification of factory control of aggregate production according to harmonized standards: SIST EN 12620:2002, SIST EN 13043:2002, SIST EN 13055-1:2002, SIST EN 13139:2002, SIST EN 13242:2003, SIST EN 13383-1:2002, SIST EN 13450:2003; for certification of factory control of masonry unit production according to harmonized standards: SIST EN 771-1:2004, SIST EN 771-2:2004, SIST EN 771-3:2004, SIST EN 771-4:2004 and SIST EN 771-5:2004; for certification of factory control of masonry mortar production according to harmonized standard SIST EN 998:2004; for certification of factory control of chimneys-components-concrete flue liner production according to harmonized standard SIST EN 1857:2003; chimneys-components-concrete flue blocks according to harmonized standard SIST EN 1858:2003; and chimneys-components-concrete exterior wall elements according to harmonized standard SIST EN 12446:2003. The laboratory's identity number as a certification body is REG2-0008-01 and as a notified body is 1374.

The certification body accreditation is for certification of factory production control related to concrete and aggregates according to the SIST EN 45011:1999 standard, by virtue of accreditation certificate No. CP-004 of 27 December 2005 from the Slovenian Accreditation (SA) institute.

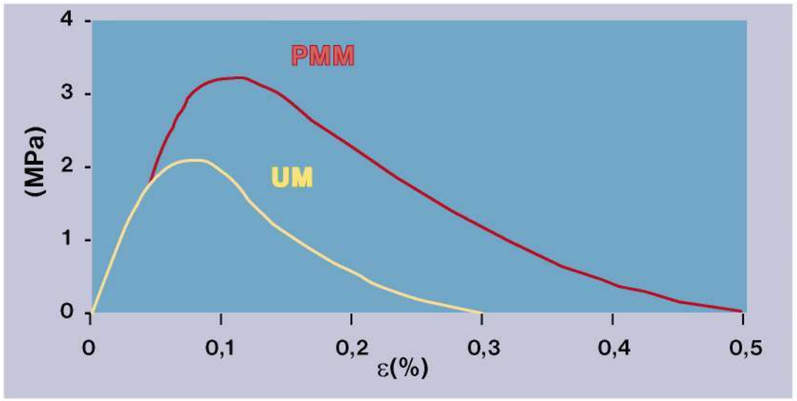


Figure 1: Characteristic - curves of PMM and unmodified mortars (UM) under tensile loading.

dependent on the latex-cement ratio. By increasing this ratio, the modulus of elasticity generally decreases, while Poisson's ratio remains the same or even becomes higher than in unmodified concrete. Characteristic σ-ε curves of polymer-modified mortars (PMM) and unmodified mortars are presented in Figure 1.

Results show that, by adding styrene-butadiene copolymer latex to mortar, ductility is increased, although the strength of the mortar also increases. Maximum flexural strength f_u increased greatly, which was determined according to the four-point bending method. With mortars 180 days old, the f_u value of PMM was 50% greater than the f_u of unmodified mortars (Figure 2).

The influence of adding fibres become evident immediately after the first crack appears in the matrix. After cracking, when external loading still has an effect, the initial energy is released by an increase of width and length of the crack. The fibres bridge the crack and do not allow the crack to propagate. Therefore, the energy is absorbed in the composite, and the toughness of the composite increases. Fibres carry internal stresses from one part of the cracked matrix to another.

The area under the load-deformation curve is a measure of the absorbed energy needed to produce a defined crack width, which leads to the concept of toughness of fibre-reinforced concrete. This toughness can be used to determine equivalent strength up

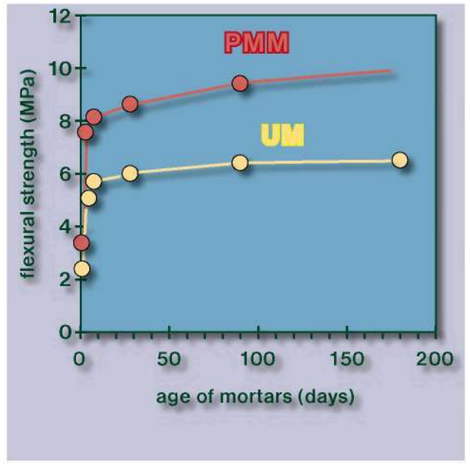


Figure 2: Maximum flexural strength fu of unmodified mortars (UM) and PMM with styrene-butadiene copolymer latex, dependent on the age of the mortars.

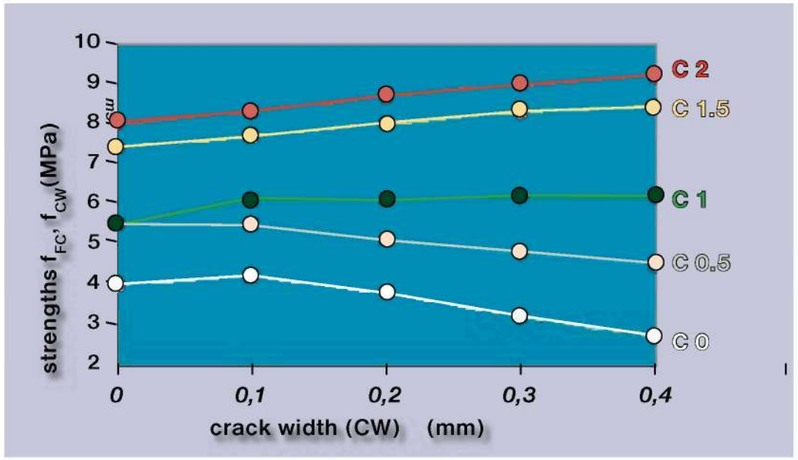


Figure 3: Influence of steel fibre content on equivalent strengths (f_{CW}) at the crack widths: 0.1, 0.2, 0.3 and 0.4 mm, and on the strength at first crack f_{FC} of 28-day-old concrete without fibres (C0) and steel fibrereinforced concrete (SFRC) with 0.5, 1, 1.5 and 2 vol.% of steel fibres (C0.5, C1, C1.5, C2).

to a selected crack width. Therefore, the crack-opening resistance of FRC should be measured in accordance with these equivalent strengths. Fibres will prevent the crack from opening only to the selected width. Concrete will have a higher resistance to crack propagation if the equivalent strength at the selected crack width is higher. In more aggressive environments, the concrete must be more durable. Therefore, crack width has to be as small as possible to prevent the entry of destructive substances into the concrete.

When a concrete element is loaded, small individual cracks begin to appear within the concrete at a certain load. These cracks then combine into a continuous crack, which becomes visible on the surface of the concrete. At this point on the load-crack mouth opening displacement (CMOD) curve, the slope of the curve increases significantly. Load and CMOD at this point are denoted as first crack load and first crack CMOD, respectively.

The significant effect of the fibres in FRC is evident when post-crack behaviour is evaluated by equivalent strengths, which represent toughness indices up to the selected crack widths of 0.1, 0.2, 0.3 and 0.4 mm (Figure 3). In this figure, average strengths at the first crack f_{FC} (CW = 0.0 mm) of all the concretes are shown to compare them with equivalent strengths f_{CW}.

Equivalent strengths at a crack width of 0.1 mm $f_{0.1}$ of all concretes are moderately higher in comparison with f_{FC} of the same concrete. After that, when the crack width increases, f_{CW} of concrete without fibres and SFRC with steel fibres up to 1.0 vol.% decreases, while f_{CW} of SFRC with 1.5 and 2.0 vol.% of fibres increase.

These results show that strain-hardening SFRC gained up to a crack width of 0.4 mm, when the contents of the steel fibres were higher than 1 vol.%. On the other hand, a strain-softening response was obtained when SFRC with a lower content of these fibres (< 1 vol.%) as well as concrete without fibres were tested in accordance with the wedge splitting test (WST).

When fibres and polymer are added to the cement composite, the mutual effect of both components on post-crack behaviour is significant, as evident in the load-CMOD curves obtained with the WST method (Figure 4). The increase in fibre content or polymer addition increases absorption energy, represented by the areas under the curves. Absorption energy increases even more when both components are added to the mortar.

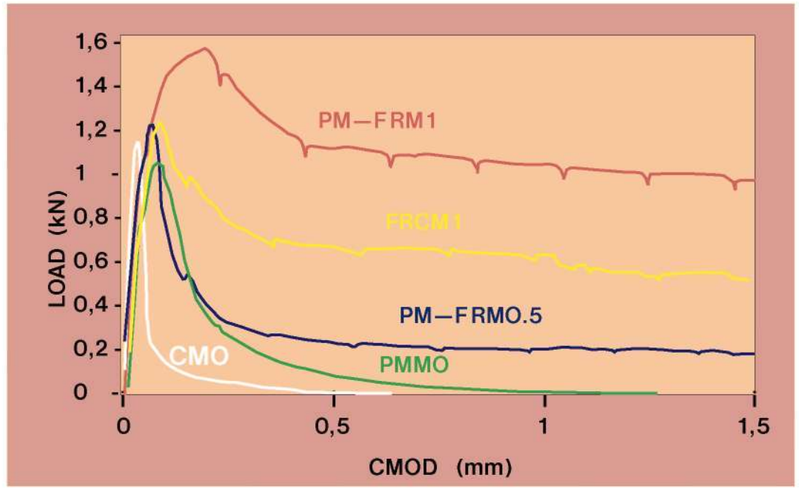


Figure 4: Typical load-CMOD curves of cement mortar without fibres (CM0), polymer-modified mortar without fibres (PMM0), polymer-modified, fibre-reinforced mortar with 0.5 vol.% of steel fibres (PM-FRM0.5), fibre-reinforced cement mortar with 1 vol.% of steel fibres (FRCM1) and polymer-modified, fibre-reinforced mortar with 1 vol.% of steel fibres (PM-FRM1).

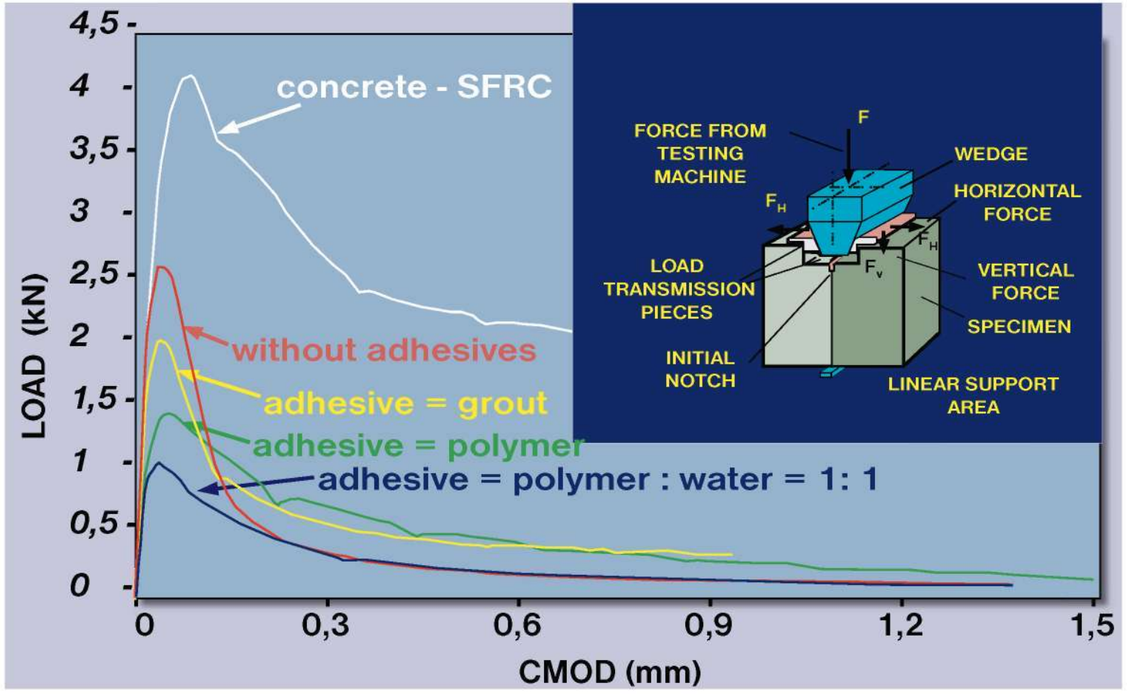


Figure 5: Typical load-CMOD curves of the bond between old and fresh PM-SFRC courses, with and without adhesives, as well as the curve of the PM-SFRC.

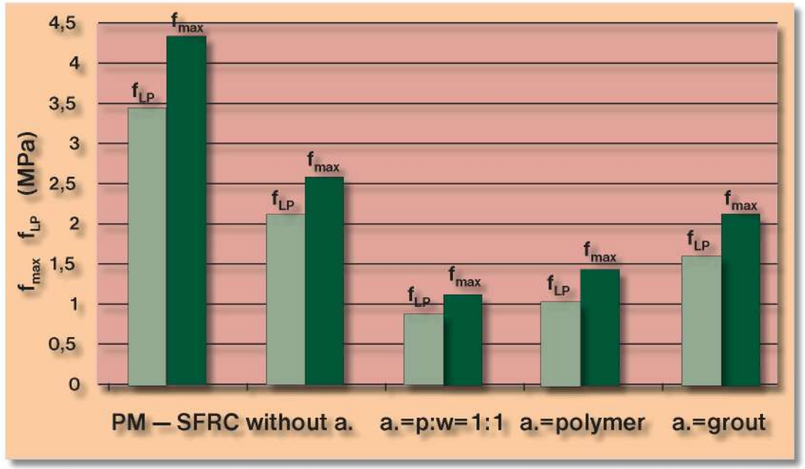


Figure 6: Average strength at the limit f_{LP} and maximum strength fmax of the PM-SFRC and of all bonding modes between PM-SFRC courses.

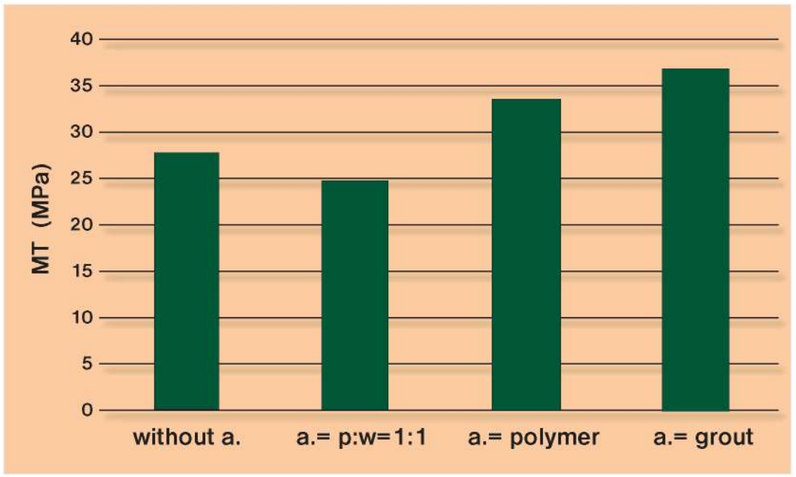


Figure 7: Modulus of toughness MT of all modes of bond between PM-SFRC courses.

Characteristics of the bond between overlay and bridge deck

Two modes of bonding between overlay and bridge deck have been applied: fresh-to-old and fresh-to-fresh concrete. A short review of the bond characteristics studied in the fresh-to-old mode is presented here.

In practice, many different modes of bonding between old and fresh concrete are used. Carefully preparation of the old concrete surface is necessary to achieve a fully bonded overlay. In the study, the surface was cleaned with water under high pressure. Excessive moisture in all areas was removed and the surface dried before grout placement. Grout made from cement, polymer and sand was used to achieve higher and effective adhesion between the old concrete surface and the overlay. Grout was applied by brush very careful to the area shortly before the fresh FRC was placed, which gave a good bond between the two concrete courses, as later proved by good performance in use.

Various parameters influence the load capacity of the bond between concrete courses. This is mainly determined by physical and chemical characteristic, and by the shape and surface preparation of the base concrete. However, some questions still remain: how well it works and which characteristics can be used to determine the behaviour of the bond under load. Answers to these questions were sought in the research project carried out at our institute. The wedge splitting test (WST) was used to determine certain properties of the bond. Values of these properties are compared with those of homogeneous concrete.

Slabs with dimensions of 1.0 × 1.0 m and 7.5 cm thick were prepared with polymer-modified steel fibre-reinforced concrete (PM-SFRC). Upper courses with the same thickness (7.5 cm) were placed on these slabs after 28 days. Before placement, the surfaces of the slabs were cleaned with water under high pressure. Four modes of bonding fresh and hardened PM-SFRC were applied:

- without adhesive,
- with adhesive = water : polymer = 1 : 1,
- with adhesive = polymer,
- with adhesive = grout = polymer + cement + sand + water.

Small blocks with an edge length of 15 cm and with an initial notch depth of 5 cm were cut from the bonded PM-SFRC courses for testing in accordance with the WST method (Figure 5). The notch was made in the direction of the bond between courses. This fracture mechanical method improves the possibilities of measuring the adhesive properties of concrete bonds. Load-CMOD (crack mouth opening displacement) curves were measured for stable crack propagation. From these curves, stress, toughness and ductile characteristics were determined. Typical load-CMOD curves for the bond between old and new concrete courses, with and without adhesives, as well as the curve of the PM-SFRC are shown in Figure 5, which also illustrates the principle of the test method.

Strength at the limit of f_{LP} and maximum strength f_{max} were determined in the direction of FH, which was obtained from the load-CMOD curve of the WST. Average f_{LP} and fmax of the PM-SFRC and of all bonding modes between PM-SFRC courses are given in Figure 6. Strengths of the PM-SFRC are higher compared to all bonding modes, as expected. The highest strengths of the bond between the PM-SFRC courses are achieved when no adhesives have been applied, i.e. the strengths of these bonds decrease with the addition of adhesives. A moderate increase is achieved when grout is used because of the cement present.

The modulus of toughness MT is used for evaluation of post-crack behaviour of the bond between PM-SFRC courses and the PM-SFRC itself. The MT shows the ductile behaviour of the bond between courses (or of the concrete) at the strength limit of f_{LP}. If a straight line is drawn between f_{LP} and brittleness factor B, which is the inverse of the ductility factor, the angle between this line and the horizontal axis represents the modulus of toughness.

In the different bonding modes reported in this section of the paper, improvement in the modulus of toughness occurred when adhesives (polymer and grout) were used (Figure 7). When the adhesive consists of a water solution of polymer, it offers no improvement in MT. This suggests that there is no reason to use such adhesives, which thus reduces application cost. There is another possibility of the use of similar adhesive material. This can be achieved when the polymer is applied as an adhesive on very moist surfaces and the water in the small pits mixes with the polymer.

Figure 8: Overlay on the bridge over the Kokra River in Kranj.

Applications of bridge deck overlays made from HP-FRC

Three applications, in bridges designed by Danilo Magajne, were realised in accordance with the project, as mentioned in the introduction. The first application was an overlay on the bridge over the Kokra River in Kranj (Figure 8); the second was an overlay on the bridge over the Soča River near Podbreg (Figure 9); and the third was an overlay on the bridge over the Sava Bohinjka River near Mačkovec (Figure 10).

High-performance fibre-reinforced concrete with steel and polypropylene fibres was used for the construction of the above-mentioned overlays. These overlays have to resist the results of freezing in the presence of deicing salt and abrasion caused by vehicular traffic. The overlays must be tight and therefore without deep cracks. When polypropylene and steel fibres are used in the concrete, the microstructure of the hardened cement is additionally reinforced, and crack propagation is arrested in the microstructure. Higher energy is needed for further crack propagation. Therefore, an increase in toughness and ductility of the FRC can be expected when steel and polypropylene fibres are added to the mixture.

Fresh concrete, mixed in the ready-mixed concrete plant, had the proper workability for placing as thin overlays. FRC was applied to the surface of the old concrete directly from the truck mixer chute or with a concrete pump. Surface vibrators – vibratory screeds were used for concrete consolidation.

Figure 10: Overlay on the bridge over the Sava Bohinjka River near Mačkovec.

After consolidating of the fresh FRC and after evaporation of the bleed water, the surface of the FRC overlay was smoothed and compacted with power floats. Quartz sand was sprinkled over the surface and before being smoothed and compacted with power floats it was wetted moderately with a solution of water and polymer. Thus the surface became more resistant to abrasion and freezing in the presence of deicing salt. Wet curing was started as soon as possible, and lasted 14 days.

The test results of properties of high-performance fibre-reinforced concrete using both steel and polypropylene fibres, which are important for the durability of overlays of bridge decks show that the appropriate mix proportions were used. The first applications described in the paper were carried out up to 5 years ago. On-going observation and the conclusions of these observations will be used in the construction of new overlays to improve several important details which significantly influence the durability of bridge deck overlays.

Figure 9: Overlay on the bridge over the Soča River near Podbreg.

By Tomaž Švagelj, DELO

Modern modelling and prototyping at the Faculty of Mechanical Engineering in Ljubljana

Recording at a Speed of up to 30,000 Points a Second

Anyone who wants to get a new product on the market as quickly as possible has to make a series of difficult calculations and technological operations, one of the most interesting of which is the automated production of very accurate replicas of physical objects. In Slovenia there are still difficulties in the transfer of knowledge from the academic sphere to the sphere of business and marketing, but it cannot be said that nothing is happening in this field.

Slovenia already has, for example, a series of (research) "centres of excellence" that supplement or are "complementary" to the networks of excellence in the 6th EU Framework Programme. Their aim is to establish and ensure the efficient operation of at least eight international competitive centres of excellence in priority spheres of research and technological development.

Each centre of this type must have a top-level multidisciplinary team of researchers from the academic sphere and from business, in other words a critical mass of knowledge with a suitable research infrastructure to allow the breakthrough of the centre to the very peak of world science and/or its inclusion in an international network of excellence. In the present period over three billion tolars have been earmarked for centres of excellence in Slovenia (the co-financing period is 2004–2006 with the possibility of drawing funds up to 2008).

From idea to prototype

In line with this project, the Faculty of Mechanical Engineering in Ljubljana has recently conceived a Global Product Realisation Centre (GPRC) within its Laboratory of Computer-Aided Design (LECAD), where research will focus above all on product development in the PLM (Product Life Cycle Management) system. In technical terms it is fully equipped to monitor a product throughout its life cycle, from the first idea to "back to nature" removal from service. The centre is headed by Dr Jože Duhovnik.

In terms of both hardware and software, the centre is conceived in such way that it is capable of performing all operations, from initial idea to the elaboration of a prototype. Before developers can really begin a prototype, there is a great deal for them to do, from analyses of functions and functionalities, via measurements of shapes and design of models, to virtual display in real space. In the case of more demanding forms from harder materials, the faculty's cutting laboratory LABOD, run by Dr Janez Kopač, leaps to their assistance.

In the analysis of a product's functions, they use a range of software some of which is developed in-house and some of which is purchased. They scan and measure the shape with a movable mechanical arm fitted with a laser measuring device. This can scan up to 30,000 points a second (!), which is sufficient not only for the surfaces of a variety of technical products up to 3.5 metres long, no matter how complex, but also for objects of animal or vegetable origin, archaeological finds and even for the elaboration of exact copies of old statues. For example, one of those from Robba's Fountain. First they would scan it with the laser, so as to obtain a digital spatial model of it. Then, on the basis of this model, they would make an exact replica from some synthetic substance and finally follow the instructions of art historians to fill in the missing parts. But this is not all, since there is also the possibility of direct milling of a replica in stone.

Of course it is easier and quicker with a synthetic substance, since a model made from ABS polymer measuring up to 200 x 250 x 200 millimetres can be made in as little as 48 hours or even, in exceptional circumstances, 24 hours.

6-axis FaroArm (left).

Part of the LECAD Lab team in the background.

Photo: Tomaž Švagelj

Powerful hardware and software.

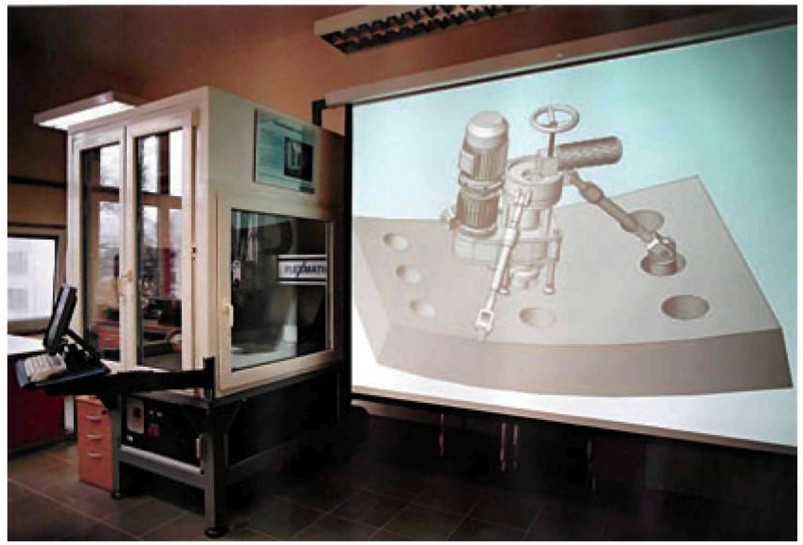
If the requirements in the case of a plastic or aluminium model are stricter with regard to accuracy, they can make prototype of an accuracy of up to 0.05 millimetres. If they only need the external form, to an accuracy of up to 0.5 mm, they use a warm jet of a synthetic substance up to a size of 600 x 600 x 400 mm.

Suitable systems for all

The GPRC is particularly suitable for ad hoc groups of experts from various fields. It already has four years' experience in international collaboration with groups for mechanical engineering and microelectronics, industrial designers and economists specialised in business economics. It is equipped with two video conferencing systems whose transmission speed is more than adequate for direct participation in a virtual room.
There are currently three active groups in the centre, devising new projects within the framework of two domestic projects and one international project. However it has sufficient capacity for at least three more groups up to the end of April 2006, when it will be occupied for six months by the participants in two other international projects. The businesses already collaborating with the centre are Niko and Domel Železniki, Iskraemeco Kranj, LIV Postojna and BSH Nazarje; the centre also collaborates with universities in other countries: Luleå University of Technology in Sweden, Delft University of Technology in the Netherlands and Wrocław University of Technology in Poland.
Through the use of new technologies, businesses can significantly improve their work and their products. The question is: how to facilitate suitable systems for different types of enterprises, including small and medium-sized enterprises. Large enterprises need very powerful PDM systems, which as well as being expensive require many additional activities such as maintenance, introduction, training, integration into business and production systems; small enterprises can make do with cheaper and simpler PDM systems. In a small development group there are no difficulties with communication among the members, while on the other hand a simple PDM system also enables easier archiving, simple use and maintenance, access via the internet, has a specific method of work built in, and so on. The new possibilities offered by the internet come into their own: work takes place via a generally distributed browser and the client does not need to install any new programs. These are the positive sides of simple PDM systems. The negative sides include above all limitations in adapting the configuration. A simple PDM system is based on a database of files to which users' access depends on the development phase of the project and their role. Not only can they search the data in the database, they can also modify it. Access to the server is via a web browser, the only program client needs. The systems are developed in their entirety by the international association of laboratories of the LECAD Group based in Ljubljana.
When a product has been developed, it goes into production and finally appears on the market. There its market value immediately begins to fall because of rival products, although this can be successfully limited through constant product development and supplementation. An extended selling period naturally increases its success on the market, since the development of a new family of products is very expensive. This framework includes minor repairs and also the preparation of totally new versions.

FaroArm measurements. 3D printer on the left.

3D model of a mobile tool designed for milling parts of a vacuum vessel for the ITER experimental fusion rector.



The aim of a PDM (Product Data Management) system, also known as PLM (Product Life Cycle Management) is to shorten as much as possible the path that begins with the conception of a product, passes through the phases of sale and service, and ends with the retirement and recycling of the product. It is vital to be able to control and review the necessary data at all times and deliver them to those who need them (and when they need them). In such a system key data are only stored once in one place, i.e. in one "copy", so that they cannot be altered or deleted by unauthorised personnel, while at the same time it is possible at all times to control, track, verify and of course save all permitted changes. Copies of these data circulate freely in the design, construction and analysis departments and among the participants in the working process, while modified or new data come back to the safe storage location. Every time something is changed, the modified copy, signed and dated, is stored in a "digital safe" alongside the previous copies, which remain in their original form as permanently archived records.

tion, especially at higher voltage. The fundamental question is that of the effect of individual components on the critical speed. Two additional questions, explain Dr Duhovnik and Dr Jože Tavčar, are linked to the usefulness of individual methods for the analysis of resonant frequencies and the effect of the properties of the components on vibrations during operation.
To end with, a brief overview of rapid modelling and prototyping. The original stereolithography technique was followed by laser "burning" of metal powder. Metal powder with a melting point of 400 to 500 degrees Celsius is locally heated with a laser beam so that it begins to melt and the particles stick together. In essence, then, the technique involves a form of local welding. All that is required is to trace the model and to switch on the laser only in those places where the model is full. Laser "burning" was followed by "powder technology", where ordinary powder, which may also be ceramic powder, is used. Liquid plastic in layers of a thickness of 0.07 to 0.15 millimetres is sprayed on to it, and then "they wait for it to react nice and slowly". If they want to speed up the process and consolidate, they additionally heat the model. This is powder technology. At the GPRC they use an artificial substance, thermoplastic ABS, which they melt and then spray in small quantity through a nozzle and with a computer-controlled 2D device apply it in the form of contour lines.

Hand tools corner.

VITEL 2006

International Symposium on Telecommunications CONTENT AND NETWORKING

Cankarjev Dom, 23–24 October

Ljubljana, Slovenia

The Electrotechnical Association of Slovenia, a Sister Society of the IEEE Communications Society, has a very long tradition of holding international symposia on telecommunications in Slovenia. The intention of these symposia has always been to concentrate on the most important and relevant topics at the time concerning efficient and useful, or simply put, viable, telecommunications for everyone. This principle also explains the name given to these symposia:* VITEL (V*iable* TEL*ecommunications). The VITEL symposium is currently organised every second year and is primarily oriented towards

Central and East European Countries.

VITEL is led by its International Advisory Committee, composed of well-known telecommunications experts mainly from the region of Central and Eastern Europe and now chaired by Prof Dr Marko Jagodič. The selection of papers and creation of the final programme is the responsibility of the Programme Committee, made up of eminent telecommunications professionals from Slovenia and presently chaired by Alojz Hudobivnik from Iskratel.

The committees decided on "Content and Networking" as the appropriate theme for VITEL 2006, with the objective of bringing together expert representatives from among operators, service providers, academia and industry to address these important topics with the goal of the more rapid implementation of emerging really broadband communications networks. The proposed theme was well received and a very interesting programme was created with speakers from 10 different countries. The organizers of VITEL 2006 were:

- Electrotechnical Association of Slovenia
- IEEE Communications Society Chapter of Slovenia
- Faculty of Electrical Engineering, University of Ljubljana
- Faculty of Electrical Engineering and Computer Science, University of Maribor
- INFOS

The VITEL 2006 international symposium focussed on problems of content generation, content provision and billing, along with problems of content access via existing and future electronic communications networks in the converging worlds of media content and telecommunications networks. During VITEL 2006 the related technical, legal, regulatory, social and economic issues were discussed and the participants came up with viable concepts and multidisciplinary methods to cope successfully with emerging challenges. The issues debated at VITEL 2006 were the following:

- Creating content;
- Social implications;
- Content access authorization and authentication;
- Architectures and models for identity management;
- Content distribution rights management;
- Content billing;
- Relations between stakeholders in content provision (content providers, service providers, network providers;
- Telecommunications infrastructure-associated requirements for content;
- Suitability of networks for content distribution and exchange (access and core networks);
- Terminals for content access and reproduction;
- Network management ensuring content access;
- The role of legislation and regulation.

The symposium took place in the well known Cankarjev Dom Congress Centre, located in the centre of Ljubljana, on 23 and 24 October within the framework of a much broader event – Hevreka!

The program of the symposium proved to be informative enough and provocative enough to stimulate fruitful discussion, giving all participants an incentive to continue their work in this sometimes rather conflicting area of telecommunications.

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J. Bešter – University of Ljubljana
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B. Horvat – Opening Session Chairman, A. Hudobivnik – Programme Committee Chairman, M. Jagodič – International Advisory Committee Chairman.

Brian Quinn, President of the International Institute of Communications.

Bosco Eduardo Fernandes, Chairman of ICTG and Mobile TV UMTS.

One of the sessions

ENTERPRISE PORTFOLIO

Hybrid MEMS

Research & Development for Industry

By Darko Belavič

Micro-electro-mechanical systems (MEMS) can be fabricated with a variety of technologies and from a range of materials. MEMS are normally made by micro-machining silicon, but for certain applications ceramic materials are a very useful alternative that can be used for ceramic micro-electro-mechanical systems (C-MEMS) or in combination with silicon MEMS. This hybrid structure is called a hybrid micro-electro-mechanical system (H-MEMS). The development flexibility is an opportunity for small and medium-sized enterprises in this fast-growing market.

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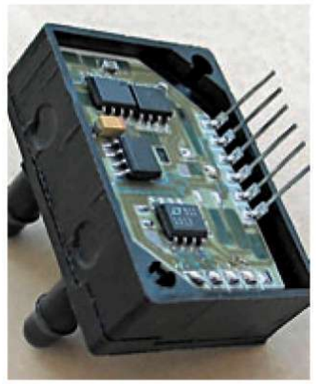
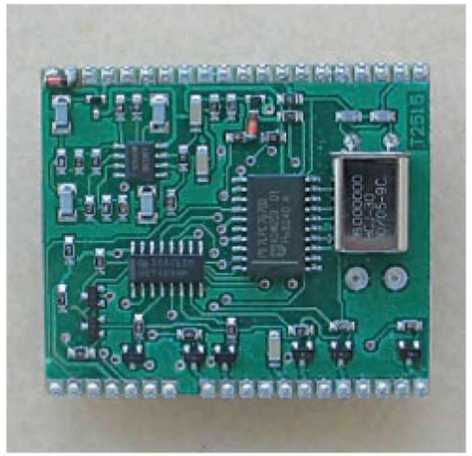
Introduction

The acronym MEMS stands for micro-electro-mechanical systems, and was used for the first time in the United States in the late 1980s. Around the same time, Europeans were using the designation "microsystems technology" (MST). MEMS are miniature devices that convert physical quantities to or from electrical signals and which depend on mechanical structures, materials and other parameters. MEMS refers to devices that have a characteristic length of less than 1mm but more than 1μm, and that combine electrical and mechanical components. A microsystem might comprise one or more sensors and/or actuators, and an electronic circuit that conditions the sensor signal and/or generates an electrical signal for the actuator. MEMS can be fabricated with a variety of technologies and from a range of materials. Most MEMS are made by micro-machining silicon, but in some applications ceramic materials are a very useful alternative. These ceramic micro-electro-mechanical systems (C-MEMS) are typically larger (meso-size) and mostly used in harsh environments. The laminated 3D structures made by LTCC (low-temperature cofired ceramic) technology are especially suitable for C-MEMS [1-8]. Both the sensors for mechanical quantities and the actuators are fundamental parts of MEMS. The most important technology for manufacturing sensors and actuators in C-MEMS is thick-film technology. A thick-film resistor can be used to sense, and piezoelectric materials can be used to actuate, the mechanical deformations in MEMS structures. Thick-film technology can be used in C-MEMS not only to produce the sensor and actuator elements themselves but also the electronic circuits for signal processing [3-6].





Packaging is an essential technology in the construction of MEMS devices. In most cases the device's development and design process is faced with strict requirements: device size is decreasing, while functions and performance are expanding, and at the same time the cost of the sensor has precise limitations. In this respect, developments in sensor technology are proceeding in two directions. The first direction is towards high-volume production, integrating all, or most, of the electronic and MEMS device functions into a single chip. The second direction is towards small- and medium-volume production with a high flexibility of applications, using one or more interconnection technologies to integrate the MEMS device(s), the integrated circuit(s) and the pas-

An introduction to Hyb d.o.o.

By Dušan Plut

Dušan Plut, General Director

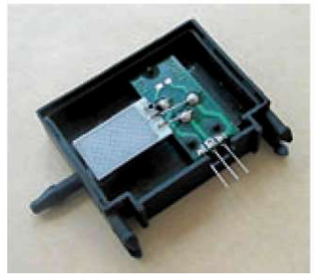
Hyb has a long tradition in the field of thick-film hybrid circuit technology. The plant in Šentjernej was established in 1972, when the first hybrid circuit was produced. In the 1980s Hyb initiated production of invasive blood pressure sensors and in the late '80s of industrial pressure sensors and transducers. In 2001 the company was bought by Novoline Holding. The owner has made significant investments 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 thick-film hybrid circuits, pressure sensors and transducers. The majority of Hyb's products are custom designed. Close cooperation with our customers throughout the development phase is crucial for the ultimate success of the end product on the market. Besides custom-designed products, Hyb also develops a proprietary brand, Hybysens.

Hyb's product line encompasses medical sensors, industrial sensors and transducers, automotive sensors, telecommunications and consumer electronics.

In the area of medical sensors, Hyb develops and produces invasive blood pressure sensors for critical care that constitute approximately 5% of the world market. The IUP sensor was designed primarily for the American market. A new generation of sensors and a complementary medical program are currently in the development phase.

Hyb's industrial sensors, transducers and switchers cover the niche of low pressure range sensors. Hyb's competitive strengths are in its flexibility and orientation to designing, producing and calibrating products for the customer.



The automotive industry is the third market sector where Hyb is present, where basic automotive products (hybrid circuit boards) are upgraded to pressure sensors and switchers. Last year Hyb started marketing its own MAP sensor, and several new products are being developed.

Since the very beginning Hyb has been cooperating with the Jožef Stefan Institute, especially with its Electronic Ceramics Department. Important R&D partners are also the Faculty of Electrical Engineering at the University of Ljubljana and the Hipot-RR company in Šentjernej.

A balanced combination of investments in basic and applied research is key in the long-term competitiveness of the company in turbulent markets, where product lifecycles are shorter and shorter, and where even the markets themselves appear and disappear. No one can afford to rest on their laurels or on current successes. At Hyb we invest in our people in all fields and encourage the creativity and innovativeness of the entire organization. Hyb constantly endeavours to gain the trust of its business partners with the best possible products and services. The same attention paid to the development of new products and the improvement of previously launched products is also devoted to the development and improvement of the process of providing high-quality service to our business partners.

sive components in a MEMS module. Thick-film interconnection technology on a ceramic substrate is essential to meet these demands. The electronic circuits for signal processing in sensor applications range from a simple amplifier to a "smart" sensor. In addition, many different electronic circuits may lead to the same function or operation. The common electronic conditioning circuit for sensor applications needs an excitation voltage or current, an instrumentation amplifier, a voltage reference and an output stage.

The market for sensors and MEMS

The global market for silicon-based MEMS devices is very difficult to analyse because of the definition of the market(s). Therefore, the results of different market analyses (iNEMI, NEXUS and Yole Development) [11-13] yield different absolute numbers, but the annual growth of the market is in all cases similar and relatively very high (about 17% CAGR). The growing MEMS market also has an influence on the markets for materials and equipment for MEMS, which are shown in Table 1. The silicon-based MEMS device market was $3.85 billion in 2004 and is forecast to reach $6.0 billion at the end of 2006 and $8.1 billion in 2008, thus resulting in a 16% CAGR.

The biggest share of the MEMS market (especially in Europe) belongs to automotive applications, which was, and still is, the major area of application and the driving force for silicon-based MEMS products. In 2004 alone, the worldwide automotive market used more than half (65%) of all the MEMS sensors produced, followed by industrial applications (about 20%), consumer-type applications (6%), and only 5% in the area of communications and computers.

Today, small and medium-sized enterprises are the driving force behind the technological development of MEMS, since these companies are able to adapt new technologies in a flexible way with short turn-around times. Most of them buy the silicon MEMS devices on the open market and use them in their innovative products.

MEMS packaging and integration

Packaging issues are very important and challenging for the applicability of MEMS because they are usually sensitive to mechanical or thermo-mechanical stresses. Due to special requirements and in particular to specific mechanical and thermo-mechanical properties, a ceramic is probably the most common substrate material for assembling silicon MEMS devices. The reason lies in its physical properties, which include: high compressive strength and hardness, thermal expansion similar to silicon, and dimensional stability. LTCC technology also has many benefits for the packaging of silicon-based MEMS. Firstly, it is possible to make cavities in the substrate in which the silicon-based MEMS can be bonded and hermetically sealed. Secondly, the match between the linear thermal expansion coefficient (TEC) of ceramics and silicon is fairly good (2.6×10^{-6}/K vs. $5\text{-}7\times10^{-6}$/K for LTCC), which is very important for sensitive MEMS devices in wider-temperature-range applications [1,3]. The combination of silicon- and ceramic-based MEMS formed in a hybrid structure is called a hybrid micro-electro-mechanical system (H-MEMS).

Table 1: World MEMS market ($ billion)

	2004	2006	2008	CAGR
MEMS Systems	29.50	41.00	57.00	18%
MEMS Devices	3.85	6.00	8.10	16%
Materials for MEMS	1.48	1.90	2.50	14%
MEMS Equipment	0.51	0.67	0.85	15%

Microelectronics and MEMS technology have completely different system-integration requirements. The microelectronics of the future will integrate increasingly complex subsystems onto a single planar chip, enlarging its size to several cm2, as it currently stands. In contrast, microsystems usually require smaller areas, which can only be produced through 3D integration. Protection against harsh environments and the special interfaces between the sensor and measurement environment are other important factors in the system integration of MEMS devices.

In most of the industrial pressure sensors produced by HYB, the sensors are built in two parts, functionally divided into a pressure-sensor front-end (Fig. 1) and an electronic conditioning circuit combined with thick-film technology. The sensor element is a silicon MEMS device (gauge silicon piezoresistive pressure sensor), which is a silicon die with a thin diaphragm in the middle. The diaphragm is formed by etching into the silicon die. Into this diaphragm four piezoresistive resistors are diffused, which are electrically connected to form a Wheatstone bridge. One of the key technologies for the successful production of pressure sensors is bonding the silicon die to the (ceramic) substrate (Fig. 2). Depending on the sensor application, different polymer adhesives are chosen to satisfy the demands of various users.

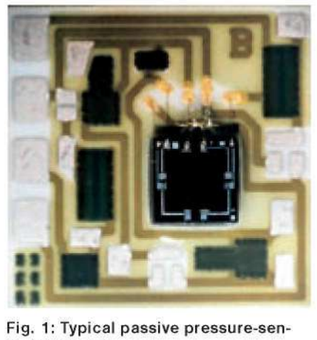


Fig. 1: Typical passive pressure-sensor front-end

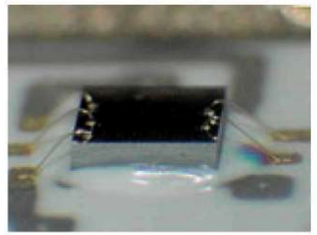


Fig. 2: The silicon die (piezoresistive pressure sensor) is bonded to the ceramic substrate

Miniaturization is a consistent theme in the development of new MEMS and pressure sensors. An example is the miniaturization of a pressure switch, as shown in Fig. 3. The miniaturisation of the pressure switch was possible by using high-density interconnections and a naked chip semi-custom ASIC.

C-MEMS made with thick-film technology on a ceramic substrate are widely used in harsh environments. In comparison with semiconductor sensors they are more robust, have a wider operating temperature range, have good long-term stability and have no organic compounds. In general, the sensitivity of such thick-film pressure sensors is lower than with silicon sensors, but the operating ranges are wider. Fig. 4 shows piezoresistive thick-film ceramic pressure sensors based on an alumina ceramic cell with bonded electronic conditioning circuits.

Fig. 3: A comparison of three generations of pressure switch (HYB d.o.o.)

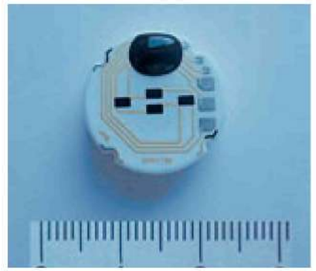


Fig. 4: Ceramic pressure sensor with ASIC for signal conditioning (HYB d.o.o.)

Low-temperature cofired ceramics

Advanced ceramic technologies, like low-temperature cofired ceramics (LTCC), are a rapidly growing part of the hybrid electronic-module market in Europe. More than 25% of this market in the year 2004 belonged to LTCC technology. LTCC technology is a three-dimensional ceramic technology utilizing the third dimension (z) for the interconnect layers, the electronic components and different 3D structures such as cantilevers, bridges, diaphragms, channels and cavities. It is a mixture of thick-film and ceramic technologies. Thick-film technology contributes the lateral and vertical electrical interconnections, and the embedded and surface passive electronic components (resistors, thermistors, inductors, capacitors). Ceramic technology contributes the electrical, mechanical and dielectric properties as well as different 3D structures [7-8].

HIPOT-R&D d.o.o., Šentjernej, Slovenia

The HIPOT-R&D Research and Development in Technologies and Systems Company was established in 1996 to act as a research organisation for local electronic components companies. Current research and development activities are organised at HIPOT-R&D through the research and development group. This group is responsible for research, development and technology transfer in the fields of thick-film hybrid microelectronics, sensors (primarily pressure sensors), electronics, electronics technologies, and electromechanical devices and systems. In the field of research and development, as well as in system upgrading, the company works closely with scientific institutions and technical associations, both in Slovenia and worldwide. The cooperation with its research partner, the Jožef Stefan Institute in Ljubljana, is traditional and goes back to the 1970s. One division of HIPOT-R&D is actually located in Ljubljana at the Jožef Stefan Institute, while the other is in Šentjernej, at the same location as its industrial partner HYB d.o.o. This distribution facilitates excellent cooperation between partners.

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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 can be laminated to form high-density interconnections and three-dimensional structures. The fabrication process includes several steps, which are termed LTCC technology (Fig. 5). The separate layers are formed by the mechanical shaping of meso-size features (0.1-15 mm), and then the thick-film layers are screen-printed. All the layers are then stacked and laminated together with hot pressing. This laminate is sintered in a one-step process (cofiring) at low temperatures

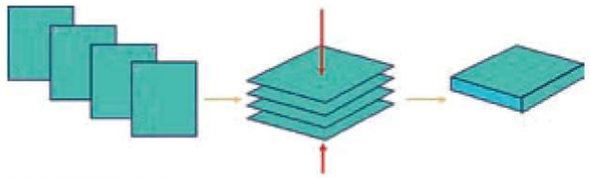


Fig. 5: LTCC technology.

(850–900°C) to form a rigid monolithic ceramic multilayer circuit (module). Some thick-film materials need to be post-fired; this means the paste needs to be screen-printed on the pre-fired laminate and then fired again. The whole LTCC process saves time, money and reduces the circuit's dimensions compared with conventional hybrid thick-film technology. The important advantage for MEMS applications is the lower Young's modulus (about 100 GPa) of LTCC materials in comparison with alumina (about 340 GPa). The disadvantages of LTCC technology are a lower thermal conductivity (about 2.5 to 4 W/mK) in comparison with alumina and the shrinkage (about 10 to 15% in the x/y-axes and about 10 to 45% in the z-axis) of the tape during sintering. An example of a MEMS application, a thick-film piezoresistive pressure sensor on an LTCC substrate, is shown in Fig. 6.

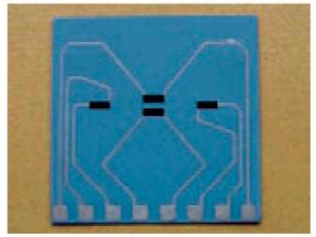
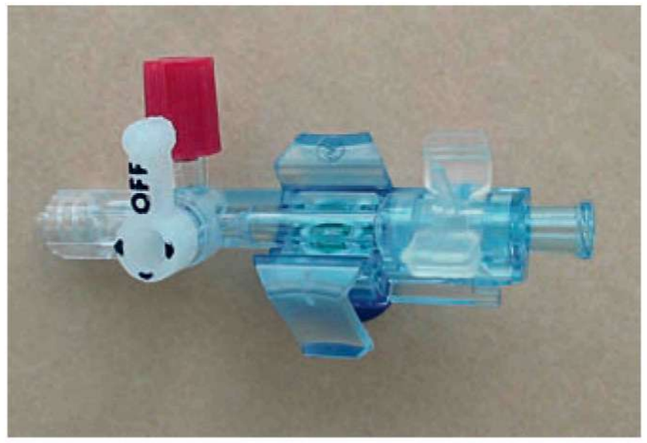


Fig. 6: Thick-film piezoresistive pressure sensor on an LTCC substrate



Research priorities

The research priorities for the next 5 to 10 years on MEMS and sensors are very important for the successful development and production of new products in the future [11]. Some of the research priorities are general, but some are specific to MEMS and sensors. Six topics with research priorities are the following:

1. Manufacturing Processes

- Manufacturing processes that support rapid miniaturization
- Significant cost reduction in manufacturing processes
- Development of new testing technologies to improve yield and reduce test costs
- In-system electrical and optical test technologies that can be incorporated into the build process
- Improved packaging manufacturing processes
- Development and deployment of surface micromachining technologies for sensors

2. System Integration

- IT infrastructure research is needed to ensure the fast and secure transfer of increasingly large amounts of data across the supply chain
- Research is needed to develop tools for meeting environmental compliance regulations cost effectively and securely
- PLIM (Product Lifecycle Information Management) security research is needed to guarantee that only the data that is needed is supplied to the appropriate supply-chain nodes
- Improved planning/PLIM methodologies that deal with ever-changing market needs over the lifecycle of a product and optimize the resources of the entire system

3. Technology Integration

- Smart sensor
- Wireless communication
- Robust and low-cost out-of-plane optical coupling, e.g. surface-mounted device to embedded waveguide
- Development of Low Voltage MEMS: Innovative MEMS structure designs, monolithic integration with ICs
- Low-cost, high-reliability, dirt-tolerant, optical interconnects

4. Energy and the Environment

- Development of a flexible, miniaturized energy supply for integration in self-contained sensors
- Development of good scientific methodologies to assess the environmental impact of materials and the potential trade-offs of alternatives
- Development of cost-effective, energy-efficient power sources
- Development of a common, meaningful, straightforward definition of sustainability

5. Materials and Reliability

- Reliable materials systems for the first level of interconnect between new device technology and new substrates, including laminate materials with higher density, competitive cost, improved dimensional stability, planarity, low moisture absorption and low warping
- New interconnect and packaging technologies deploying nanomaterials supporting decreased pitch and increased frequencies
- Polymers will be used for MEMS devices
- Low-cost, higher thermal conductivity packaging materials, such as adhesives, thermal pastes and thermal spreaders, need to be developed for use in products ranging from high-performance computers to automotive applications
- Improved materials for energy sources and energy-storage systems
- Next generation of lower-cost solder alloys
- Realization of the potential for embedded sensors will require the development of miniaturized sensor elements, integrated control systems, and micro-actuators that can all be interconnected in a single package with a small form factor
- Biocompatible materials for the packaging of biosensors backed by long-term reliability and safety data
- Miniaturization is especially critical for implantable devices, and one of the keys to achieving this is the availability of ultra-small, stand-alone power sources with a long life. Although continued research into miniaturized fuel cells is required, this area may benefit from breakthrough developments in nanotechnology for energy-storage devices.

6. Design

- Co-design of mechanical, thermal and electrical performance of the entire chip, package and associated heat-removal structures
- Mechanical and reliability modelling
- Thermal and thermo-fluid simulation
- Thermo-mechanical models for nanoscale-level technology, such as experimental tools capable of measuring electrical, thermal and mechanical phenomena/material properties at smaller scales, for which scale-dependent algorithms will be needed that have the ability to shift scales
- Simulations (thermal and mechanical) for optimizing hybrid lamination schemes for electrical and optical needs
- Improved and integrated design tools for emerging technologies like embedded passives, nanotechnology, and opto-electronic PCBs, including low-cost, fine-line substrate and PCB routing technologies enabling denser package I/O and multi-physics simulations (e.g. Joule heating in sub-50-nm interconnects, electro-chemical phenomena in bio-MEMS devices)
- Integrated mechanical, electrical and thermal package/product design
- Integrated design and simulation tools needed for RF modules and devices
- Modelling and simulation of spin as electrons move through different materials; spin relaxation modelling

HYB d.o.o., Šentjernej, Slovenia

The HYB Hybrid Circuits and Sensors Company (which is in the SME category) has had experience in the production of custom thick-film hybrid circuits since 1972 and experience in the production of pressure sensors for medical applications since 1986, and for industrial applications since 1994.
A thick-film hybrid circuit can be described as a small, self-contained electronic circuit (module) made up of a ceramic substrate with applied thick-film technology and a variety of different component types mounted on it using various assembly techniques. The markets for these products are mainly where reliability, space and weight are at a premium. Moreover, in most cases the customer provides these and other special performance requirements. This is known as a custom-designed hybrid circuit. HYB has the technical staff to handle all aspects of the design and manufacturing process.
HYB is a renowned European designer and producer of pressure sensors for medical and industrial applications. The company is able to design, develop and manufacture pressure sensors with silicon or ceramic sensor elements and the required signal conditioning electronic circuitry.

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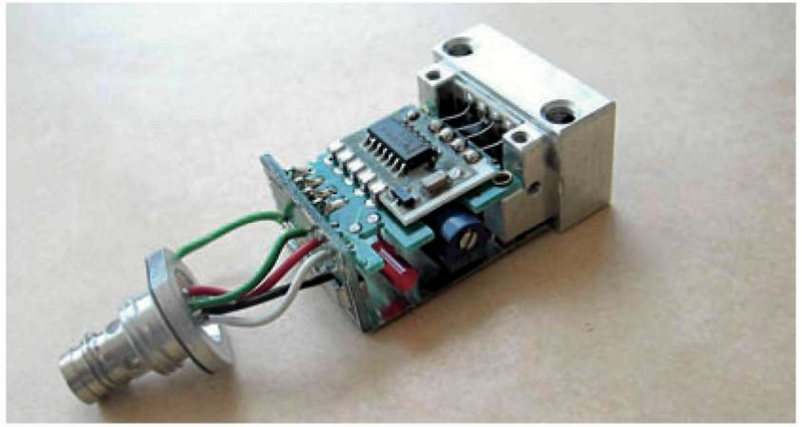
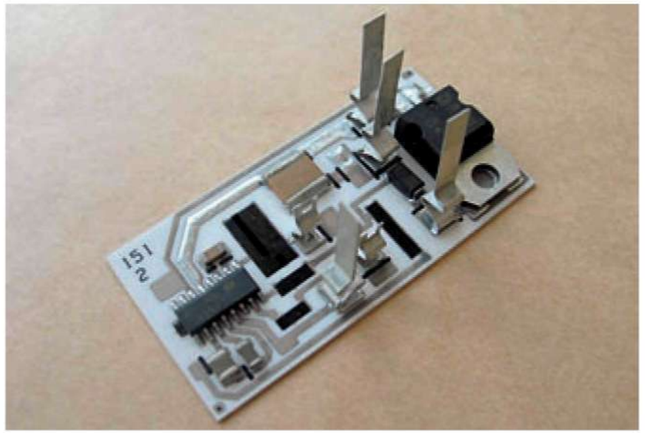
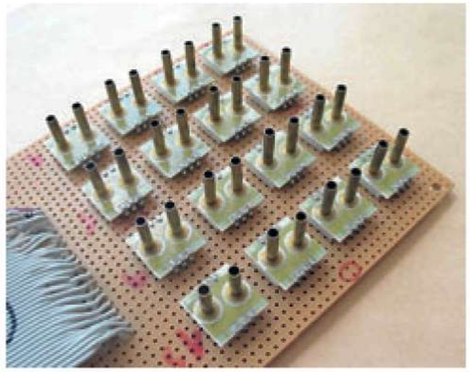
Technology needs in the next ten years

Realization of the potential for embedded sensors will require the development of miniaturized sensor elements, integrated control systems and micro-actuators, which can all be interconnected in a single package with a small form factor.

Packaging technology must evolve towards higher levels of integration using system-in-package solutions, sometimes as an intermediate step towards eventual system-on-chip implementation.
The iNEMI (International Electronics Manufacturing Initiative) recommends [12] more aggressive development and deployment of surface micromachining technologies for sensor components, as well as lithography, electroforming and moulding processes for the high-volume production of integrated sensor/actuator systems. This is a process involving forming structures in a polymer mould photo-lithographically, and then electroplating into these cavities.
Advances in microelectronic fabrication technologies combined with system-on-chip design will lead to the rapid development of the control systems needed for smart embedded sensors [12]. These needs especially affect the automotive industry, which currently utilizes a multi-package module for many sensor applications that require the integration of sensors, microprocessors, signal conditioning, communications, power source and memory functions.







Among the main non-technical barriers to sensor-technology development are the lack of adequate cross-disciplinary collaboration, qualified human resources and the lack of widely established and accepted standardization – especially with respect to communication protocols [12]. Ultimately, these non-technical barriers can be best addressed through closer cooperation between industry and academia in order to cultivate a technical workforce capable of developing and communicating innovative ideas that cross traditional disciplinary boundaries.

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Ceramic materials in MEMS applications

By Marija Kosec

Development trends in the field of electronic components, sensors and packaging technologies are tending towards miniaturisation and integration of various functions. The research community consists more and more of scientists and engineers from different disciplines; particularly obvious is the collaboration of materials scientists with electronic engineers. Materials in this industry continue to have significant influence on meeting the major manufacturing requirements of integration for smaller size, higher reliability, greater functionality, higher bandwidth, environmental friendliness, lower cost through increased modularity, etc. This also holds for electro-mechanical systems (MEMS), but in addition to the electronic performance of materials systems, there are also product-specific materials requirements: mechanical, electro-mechanical, chemical and, in some cases, optical performance. Common MEMS are made by micro-machining silicon, but there is a place for ceramic materials as well. Ceramic materials and technologies in MEMS production can be used on three levels. The first level is the fabrication of sensors and actuators as an integral part of the MEMS. Typical examples are piezoelectric materials for actuators and/or sensors and thick-film resistor materials for sensors. The second level is ceramic-based MEMS, which can be made as a 3D structure using advanced ceramic technologies. These ceramic MEMS are typically larger and are mostly used in harsh environments. The third level is the package for MEMS, which are the most widely used ceramic materials in MEMS manufacturing. Ceramic materials are suitable for packaging because of their mechanical, chemical, electrical and thermo-mechanical properties.

Prof Dr Marija Kosec,
Head, Electronic Ceramics Department
Jožef Stefan Institute.

Dr Marko Hrovat, coordinator of several research projects.

Dr Marina Santo Zarnik, co-ordinator of several research projects.

To fulfil the demanding requirements of MEMS technology, intensive research on new materials and their applications is required.
The Electronic Ceramics Department at the Jožef Stefan Institute is involved in research, education and development of materials that are closely related to application in electronics, mainly complex multifunctional materials and structures. Materials of interest include ceramic piezoelectrics, ferroelectrics, relaxors, "conductive" oxides and materials for solid oxide fuel cells (SOFCs). The emphasis is on the creation of properties through synthesis and structure on the nano-, micro- and macro- level. The Institute's research staff have experience with various technologies such as tape casting, spin coating, screen printing, electrophoresis deposition as well as thorough structural and functional characterization.
In the field of MEMS technology the department traditionally works with strategic research partner HIPOT-R&D and industrial partner HYB. The department is also involved in many research projects or other forms of cooperation in Europe and worldwide.

Mitja Jerlah by the high precision screen-printer.

Fibre Optic Sensors: State-of-the-Art Technology Becomes an Emerging Industrial Reality

By Denis Đ onlagić

Introduction

Back in the seventies, only a few years after the invention of low-loss optical fibre, it became apparent that optical fibre can not only reliably transmit data, but also provide remarkable sensing capabilities. These sensing capabilities combined with unique properties offered by optical fibres, such as total dielectric design, complete immunity to electromagnetic interference, small size, capability for distributed sensing, explosion safety and good bio-compatibility attracted significant attention in both industry and academia. Over the past two decades, fibre optic sensors have evolved from first demonstrations to practical applications. For instance, a fibre gyroscope has penetrated firmly into the commercial aerospace market, demanding civil engineering applications have started to rely on data collected by distributed fibre optic sensors, and there is an emerging market for fibre optic biomedical devices, etc.

The LEOSS team (left to the right): Assoc Prof Dr Denis Đ onlagić, head of LEOSS; Dr Edvard Cibula; Dipl Ing Matjaž Linec; and Dipl Ing Marko Kežmah

For over a decade, fibre optic sensors have been the subject of intense research at the Laboratory for Electro-Optics and Sensor Systems (LEOSS) at the Faculty of Electrical Engineering and Computer Science at the University of Maribor. We have developed various innovative fibre optic sensing concepts that are advancing towards industrial products through collaboration with domestic and foreign industrial partners. This article briefly describes some of the Laboratory's recent activities and efforts towards industrialization of our research results.

Faculty of Electrical Engineering and Computer Science

The Faculty of Electrical Engineering and Computer Science is part of the University of Maribor, Slovenia

Within the Faculty, academic studies and research are carried out at the following institutes:

- Institute for Automation
- Institute for Electronics
- Institute for Information Systems
- Institute for Mathematics and Physics
- Institute for Media Communications
- Institute for Power Engineering
- Institute for Computer Science
- Institute for Robotics
- Institute for Telecommunications.

Teaching and research activities at the Faculty are the province of 21 professors, 20 associate professors, 16 assistant professors, 11 senior lecturers, 74 teaching assistants, 43 researchers, and 76 technical and administrative staff members.

We offer two separate directions in our undergraduate study programmes, each leading to a different type of degree: academic and professional. Five undergraduate study programmes lead to academic degrees (Electrical Engineering, Computer and Information Science, Telecommunications, Media Communications and Industrial Engineering – Electrical Engineering option), while two additional study programmes lead to professionally oriented degrees (Electrical Engineering and Computer and Information Science). In the academic year 2005/2006 we enrolled 2,714 students, of whom 2,013 are full-time and 701 are part-time students.

Two postgraduate programmes are currently being offered: Electrical Engineering and Computer and Information Science. We have 317 postgraduate students for the academic year 2005/2006.

Research plays a vital role in the activities of the Faculty of Electrical Engineering and Computer Science. The Faculty offers a wide variety of different and developing fields, and as such, the only possible way to be successful is to build on the solid foundation and strength of the scientific research work of our professors, assistants and researchers. That is why one of the most important aspects of our current pedagogical activity is keeping abreast of the latest scientific advances in the world and being creative and collaborative in the development of our own research work.

The Faculty has also a strong tradition of applied research for industry. On average, about 100 industrial projects are realised at the Faculty each year. Students are actively involved in many of these projects, which gives them the necessary experience for success in their future careers.

Other evidence of the Faculty's stimulating environment is also the record of excellent results in various student competitions. In 2005 a group of 4 computer science students won the MS Imagine Cup for Eastern Europe (the competition took place in Greece) and ranked 6th at a world competition in Japan.

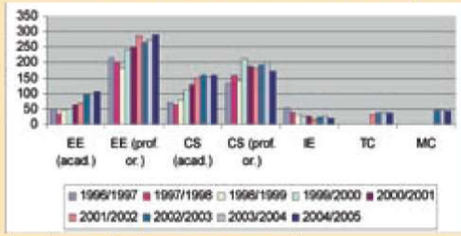
At our Faculty we have also participated in a variety of international projects and have published important research findings in the most prestigious scientific publications. Our work has been well recognized by foreign scientists, and many of our ideas are protected by international patents. Our researchers have also been educated at various renowned foreign universities and institutes.

Our 7 programme units, registered with the Slovenian Research Agency, are Telematics, Control of Electromechanical Systems, Mechatronic Systems, Advanced Methods of Interaction in Telecommunications, Information Systems, Applied Electromagnetics and Computer Systems, and Methodologies and Intelligent Services. The work in these programme units represents the basis of fundamental research at our faculty and includes the majority of our researchers.

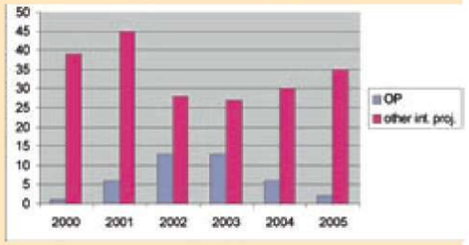
The Faculty of Electrical Engineering and Computer Science has been actively involved in many bilateral R&D projects with numerous countries throughout the world, especially in Europe, with participation in many EU projects and programmes (FP5, FP6 and other EU projects).

Dean Prof Dr Igor Tičar

Number of full-time students in the 1st year



International projects



National projects

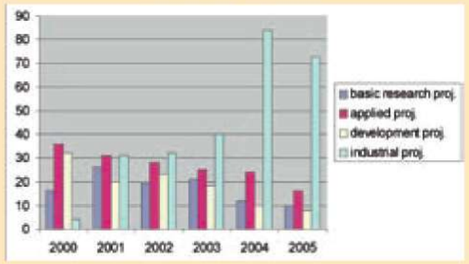


Fig 1: Live road installation of an experimental fibre optic axle detector near Sp. Polskava.

Putting fibre optic sensor on duty in extreme environments: Vehicle axle detectors for roadways

Increasing road traffic requires a more efficient system for the monitoring and intelligent control of road management systems. Vehicle axle detectors are sensor devices that are useful in a variety of transportation applications ranging from traffic monitoring, automatic tooling, automatic vehicle classification, etc. Current vehicle axle detectors mostly rely on piezoelectric arrays, which have proved to be expensive, difficult to install and not sufficiently robust to operate in extremely harsh environments such as the upper asphalt layer of road surfaces. In 1999, Mikrobit d.o.o., a small Slovenian enterprise located in Murska Sobota, and LEOSS began to developed a reliable vehicle axle detector for roadways. After preliminary testing we started a formal three-year project in 2003 that resulted in a robust, cost-effective and easy way to install vehicle axle detectors. The prototype is now being developed into a commercial product.

Optical fibre has two important properties that make it a likely candidate for the design of vehicle axle sensors: it is made of fused silica, which is one of the most elastic inorganic materials known and which allows for the design of long-gauge sensors. The first property allows installation of the fibre into the upper layer of road asphalt, where shifts and drifts of the layer geometry over the expected lifetime of the sensors can be expected. Second, the axle detector is in essence a long-gauge sensor, i.e. the length of the sensitive area can span the entire road lane to provide reliable detection of vehicle axles.

We investigated a variety of different approaches. For this purpose we established a test polygon in a section of unused freeway in Hoče near Maribor. Various concepts and sensor designs were tested, ranging from Michelson and Sagnac interferometers, microbend and some other fibre sensing concepts. Several designs were then installed in live roadways. A few of those designs were developed into practical prototypes. Figure 1 shows the installation of a fibre optic axle detector in a live roadway located in Sp. Polskava. Figure 2 shows the typical sensor response during passage of a heavy vehicle. Further development has been carried out to improve cost effectiveness and sensor lifespan. Part of this work was published and received an IEEE Vehicular Technology Society Award for the best land transportation paper published in 2003.

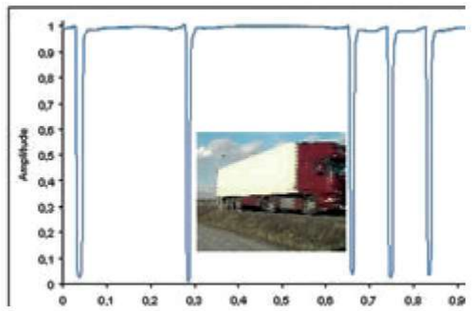


Fig. 2: Typical sensor response to passage of a 5-axle truck at Lipovci near Murska Sobota.

Micromachining the fibre tip: A method for creating cost-effective, ultra-miniature, all-silica fibre sensors

Intensive research efforts have been directed into the development of advanced micro-opto-electromechanical systems (MOEMS). At LEOSS, we developed a special method that allows for quick and cost-effective micromachining of the fibre tip. The method is suitable for low-cost mass production; it does not require lithographic masks and can be performed in large batches. Essentially, the technique is based on the fact that the doped silica glass etching rate in HF or buffered HF depends on the local dopand concentrations. Fibre with an appropriate dopand distribution is produced by one of the well-established fibre manufacturing techniques (such as MCVD). The fibre is then cleaved and appropriately etched (in batches when desired). Typical examples of structures created on the tip of the fibre are shown in Figure 3.

By splicing these structures with ordinary fibres or one to another, a variety of interesting optical sensors or other miniature devices can be created. Figure 4 shows examples of a microlens and an in-fibre strain sensor. The microlens is attached to the tip of the fibre and measures about 65 µm in diameter. The strain sensor measures only 125 µm in diameter. Figure 4 also provides a comparison of strain sensor response to the reference conventional resistive strain gauge.

Further development of this technology allowed for design and production of one of the smallest pressure sensors ever made, as shown in Figure 5. The sensor is only 125 µm in diameter and features an all-silica design. Since the sensor is fully fusion spliced and does not contain any adhesives or bonding materials, it therefore exhibits a broad temperature range (more than 500 °C) and excellent temperature stability.

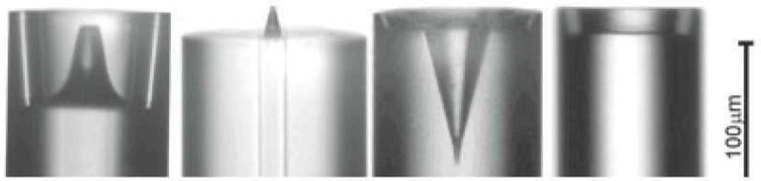


Fig. 3: Various structures formed at the tip of an optical fibre.

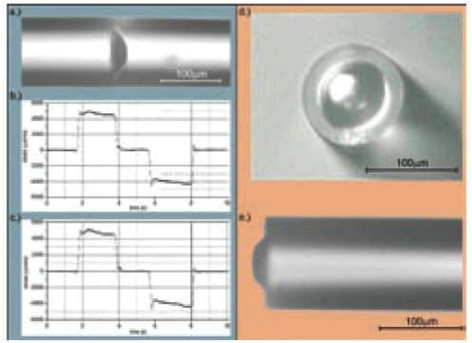


Fig. 4: a) In-fibre strain sensor; b) string gauge response; c) fibre strain sensor response; d) and e) microlens at the tip of an optical fibre.

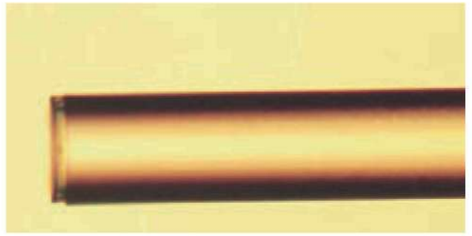


Fig. 5: Miniature all silica pressure sensor.

A special technique for production of a very thin diaphragm was developed that uses on-line control of the diaphragm thickness during the manufacturing process. This allowed us to achieve the high sensitivity that makes this sensor suitable for measurements of low pressures such as those encountered in biomedical applications. In 2005 LEOSS established long-term collaboration with one of the major fibre optic sensor suppliers, FISO Technologies Inc., Canada, to further develop and commercialize this technology. In 2005 LEOSS and FISO jointly filed three international patent applications.

Fig. 6: Specialty fibre production at Optacore.

Specialty optical fibres: A way to make optical sensing technology more cost effective

LEOSS has been actively involved in the research and development of specialty optical fibres. This effort started in 1996 when we developed the first special fibres for distributed sensing.

This work was done in collaboration with Fotona d.d. Unfortunately, Fotona discontinued fibre production a few years later; however, LEOSS actively continued specialty fibre research work that resulted in special fibres that are extremely resistant to bend-induced losses. Some of this work was later acquired by Corning Inc., the largest optical fibre manufacturer in the world. Recently, specialty fibre production was re-established in Slovenia. Figure 7 shows the typical performance of the patented bend resistive fibre system compared to conventional and other special bend restive fibre. LEOSS closely collaborates with Optacore d.o.o., a small enterprise dedicated to MCVD fibre manufacturing technology. In collaboration with Optacore and FISO Technologies we recently developed a variety of specialty fibres that further advanced our MOEMS sensors. The fibres developed allow for a more cost-effective sensor production process. Other current activities in fibre design and manufacturing are directed towards the development of new optical fibres for distributed sensing, high temperature fibres, special bend sensitive/insensitive fibre profiles and fibres for specialty telecommunications applications.

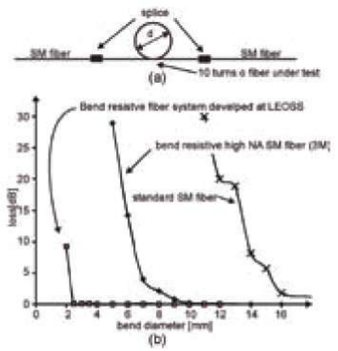


Fig. 7: Bend resistive optical fibre: a comparison of by LEOSS developed system to standard single-mode fibre and special bend resistive fibre produced by 3M.

Searching for further industrial opportunities for optical fibre sensors

While conducting basic research to improve the understanding of waveguide properties of optical fibre sensing devices, LEOSS continues its state-of-the-art industrial research. We have been researching and developing new cost-effective industrial sensing concepts and applications. An example of such recent work is shown in Figure 8, where we were looking into the possibilities of introducing fibre sensing technology into cost-driven applications such as the automotive sensor sector. We developed a special quasi-distributed anti-squeeze sensor that prevents accidental closure of a car window when an object (like a human hand) is in the way, as required by new EU car safety directives. The sensor we developed relies on the application of plastic optical fibre and opto-electronic components that are already in use in the automotive market.

Fig. 8: Low-cost distributed fibre optic anti-squeeze sensors: effective protection against injuries caused by electric car windows.

Fotona: Producing the Highest Performance Laser Systems for Over Forty Years

Fotona began life in 1964 (the same year that the first Neodymium laser was created) as an optical research laboratory, and quickly became one of the fastest-growing high-tech companies in Slovenia, specializing initially in high-sensitivity optoelectronic laser equipment for the defense industry.
It entered the medical laser market in the early 1980's with the highly-demanding manufacture of ophthalmic laser equipment, and has been at the forefront of medical laser technology ever since.
Lasers have remained at the heart of Fotona's technology. Today, Fotona is involved in four areas – defense, communications, industry and medicine – with their major focus centering on medical laser equipment.

Introduction

Despite the popular conception of Lasers as being futuristic and the stuff of science fiction, lasers have been with us for over 40 years, with their range of applications growing steadily all the time. The word Laser itself is an acronym that stands for **Light Amplification by Stimulated Emission of Radiation. Laser light is characterized by the following properties:**

- The light it emits is **monochromatic** - in other words it contains one specific wavelength of light.
- All photons travel together in phase so that the light released is **coherent**.
- Finally the photons all travel in the same direction (**unidirectional** or **collimated**).

Since their creation lasers have spread into numerous industries. Today lasers are widely used, in a myriad of ways, in defense, communications, industry, scientific research and medicine. In the medical field, doctors use them to perform bloodless surgery, to correct sight defects and to treat many dermatological conditions. In everyday life, lasers are found in numerous household products while, via fiber optic cables, lasers have become the cornerstone of modern telecommunications.

Harold Maiman invented the first operable 'ruby' laser in 1960, closely followed by the first Carbon Dioxide and Neodymium lasers four years later. Fotona has therefore been involved with lasers since their very conception, giving the company unrivalled experience and expertise. In those first pioneering days Fotona was involved in the development of gas lasers for scientific applications and then in solid-state lasers. From here, work developed on laser-based distance-measuring instruments and laser rangefinders for defense applications. These, in turn, created the basis for the development of a wide range of laser-based technologies and applications in medicine, communications and manufacturing.

The laser industry has grown and matured since its birth in the 1960s and the technology and the range of applications that use lasers continues to evolve and develop at a remarkable pace. Consequently the market for laser-based technologies has grown enormously. Fotona has been at the forefront of this dramatic change since the beginning. Today the laser industry is becoming more and more specialized, with new applications continually being investigated and developed.

Fotona's headquarters in Ljubljana, Slovenia

Fotona's revolutionary S-11 Scanner

Slovenia entered the European Union in 2004 as the most prosperous of the 'accession states' and in 2007 will be the only one of them to join the European single currency - the Euro – further evidence of its financial strength and stability.

Slovenia enjoys a strategically advantageous location in south central Europe, located between Italy to the west, Austria to the north, Hungary to the east and Croatia to the South. The country boasts excellent transport links, including Ljubljana International Airport, a modern and extensive highway network and port and cargo facilities in Koper.
Increasingly popular with foreign investors and tourists, the country's stunning natural beauty, historic towns and castles and its charming and picturesque capital, Ljubljana, are rapidly putting the country on the international map.
Most would be surprised, however, to learn that Slovenia is also home to one of the world's leading manufacturers and producers of laser systems - Fotona d.d., located in Stegne Industrial Park, close to the center of Ljubljana.

Dr Matjaž Lukač, president of Fotona:

The secret to our success is each and every employee's identification with Fotona and its passion for perfection. While we pursue perfection in everything we do, we are particularly committed to provide the most advanced and capable, as well as the safest and most reliable laser systems in the world. We are proud of our worldwide reputation for making laser systems that last "forever". Hence our maxim: "the highest performance, best made laser systems in the world". There is no other company in the world that can be better in this regard than Fotona with its unique in-house R&D, manufacturing and testing capabilities.

Dr Matjaž Lukač, president of Fotona.

Fotona has been an innovative, technology-based company since its birth in 1964, and their laser systems are the result of that experience and of their know-how and expertise in the fields of medicine, communications, industry and defense. As a consequence, Fotona is recognized as a world leader in the innovation, development and manufacture of laser systems.

From very modest beginnings, Fotona has grown into one of the leading manufacturers of laser systems in the world. Since their inception over 40 years ago the company has installed over fifteen thousand specialized laser systems all over the globe.

Quality Control on Precision Handpieces

High-Precision Machining Centers

Commitment to Quality

Dedication to strict compliance with the most stringent military standards is one of Fotona's principal attributes. Unlike many others within their field, Fotona itself produces most of the components that are used in their laser systems 'in house'.

This means that the company can ensure the quality and reliability of its systems. All of the products the company manufactures are stringently tested to guarantee that their laser systems are of the highest quality, reliability and durability and in compliance with all applicable international standards.

This dedication to quality has resulted in certification to a whole series of international standards including ISO 9001:2000, ISO 13485:1996, ISO 13485:2003, EN 46001, MDD 93/42 Annex II.3 standards, and the United States GMP standards. All Fotona's medical products comply with the requirements of the EU Medical Devices Directive, while their industrial products comply with the requirements of the EU Low Voltage Directive. Individual specific products are also certified and/or approved in the countries where they are used (for example, the FDA in the USA). Additionally, regardless of their application, all of Fotona's systems are submitted to strict temperature and vibration tests in line with military standards.

Technical Expertise

Since Fotona produce the overwhelming majority of their technology in-house, they are not simply an assembly company, but are involved in every stage of the production and manufacture of laser systems, from research and development through to the finished product - literally 'from the drawing board'.

Their facilities include modern CAD-linked CNC machines which ensure the precision and speed of production of complex mechanical subassemblies.

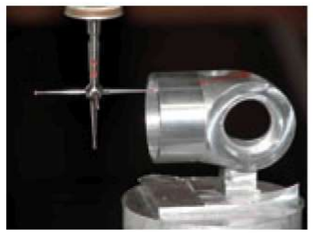
These machines are able to process cast stainless steel, aluminum alloys, bronze or synthetic substances. Fotona also boasts an optical manufacturing facility where precise optical parts can

be cut, milled, ground and polished to produce flat mirrors and optics as well as curved, shaped lenses. The facility is also able to perform thin-film coating, a technically complex procedure where evaporated metals are deposited to provide different coatings for mirrors and lenses, giving them different optical qualities.

As well as their unique 'in house' manufacturing and testing capabilities Fotona has long-standing technical partnerships with the University of Ljubljana's research laboratories.

Indeed the company played a pivotal role in helping to establish their undergraduate and postgraduate programs in Laser Physics. Fotona also collaborates with a number of universities and research institutes worldwide.

These relationships enable the company to introduce new technologies and processes which continue to ensure that Fotona's laser systems are among the most modern, efficient and technologically-sophisticated available.



Precise Component Control

Skilled Personnel

All of Fotona's key technical staff each have over ten years experience in their respective disciplines. Many hold advanced degrees or doctorates from leading American or European universities (approximately 27% of technical staff have Masters equivalent qualifications, or higher, in science and engineering), while others have had research experience in such institutions.

Such expertise provides the company with unique advantages, ensuring, among other things, a highly innovative and diligent research and development department that is constantly exploring how new technological advances can be incorporated into both new and existing systems to ensure that Fotona remains a by-word for innovation in laser technologies.

Dedicated Laser Assembly Line

From Defense to Medicine

As laser technology developed so did the range of practical applications for the technology - from the defense and military sectors into communications technology and also into medical laser systems.

Fotona first began producing lasers for use in defense and communications and subsequently moved into industry and medicine. While these industries may appear quite diverse, what connects them are shared technologies: lasers, electronics, optics and mechanics.

The first practical applications for laser technologies were in the precise measurement of distances. These found

Sophisticated Defense Observation System.

their practical application in rangefinder technologies in the defense industry. Fotona consequently began its commercial operations by producing rangefinders for tanks and artillery. Today Fotona maintains its defense arm,

Laser Rangefinder Binoculars.

Optical Communications Traffic Control Systems.

producing equipment that services the entire spectrum of products for a modern army. These include observation instruments, fire control systems, control systems, laser irradiation detector systems, thermal imaging systems for night vision and anti-tank missile guidance.

Fotona has been involved in optical network technologies for telecommunications for over 20 years, producing hundreds of optical communications devices and systems, in addition to thousands of kilometers of optical fibers and cables. Fotona has also built and commissioned over 200 microwave and SDH optical links, not only in Slovenia, but also in foreign markets - especially in Southeast Europe and Russia. Their experience, know-how and expertise allow the company to be quick, flexible and able to satisfy customer requirements.

Medical lasers – transforming aesthetics, dermatology and dentistry

Advances in laser technology resulted in the technology quickly finding uses in medicine, including surgery, aesthetics and dentistry. Fotona's pedigree, experience and know-how meant that, as these new markets emerged, the company was uniquely placed to move into these sectors. Since the 1980s these markets have shown enormous growth. For example, by 2005 the US aesthetics market alone was valued at more than $400 million. Total commercial revenues for lasers worldwide are estimated to be in excess of $2 billion.

Fotona was one of the first companies to move into the medical laser market. The technology and know-how inherited from its pioneering early work, combined with its unique advantages, have seen the medical laser market become the leading commercial market for Fotona's products. The company produces the largest range of laser systems available to meet the demands of medical professionals, dental practitioners, and increasingly spa and other non-traditional customers. The product range serves all the aesthetic market segments from entry-level systems to versatile combination lasers that are able to treat an enormous range of applications.

The largest segments of the growing market for lasers in aesthetics and dermatology are laser hair removal and skin rejuvenation. Other markets include acne treatments, tattoo removal, vascular and pigmented lesion removal and endovascular laser treatment. Fotona produces systems specifically designed for each of these applications, as well as combination systems that are able to fulfill multiple applications.

A Fotona dental laser system in operation.

In both dentistry and aesthetics Fotona continues to innovate. Its latest dental laser system, the Fidelis Plus III, is the only laser that can achieve ablation speeds faster than conventional dental drills. In addition, the combination of Er:YAG and Nd:YAG laser sources means that the system can perform both hard tissue procedures, such as cavity preparation, as well as soft tissue procedures, such as frenectomy, gingivectomy, gingioplasty etc. Furthermore, the Fidelis Plus III also has a unique dermatology upgrade option, which will allow dental practitioners to offer facial aesthetic procedures.

Fidelis Plus III – Fotona's latest Dental Laser System,

In the aesthetics market the latest system available from Fotona is the Fotona XP MAX. This system comes with a unique scanner that not only has the fastest scanning speeds and the largest scan area available on the market, but also is the only scanner available that has three spot sizes – 3, 6 and 9mm. In addition Fotona's scanners use a unique sequence of optimal laser spots to ensure the highest levels of patient comfort. Drawing on the success of the Fotona Dualis^{XP} range, the XP MAX is a clear example of Fotona's commitment to produce the highest performance, best-made laser systems in the world.

Fotona XP MAX – Fotona's leading Medical Laser System

Conclusion

Fotona's corporate slogan is 'Choose Perfection', a slogan that is reflected in strong investment in outstanding research and development facilities to ensure that the company delivers innovative solutions to this ever-changing and developing market. This, in turn, ensures that the company's philosophy of producing the highest performance, best-made laser systems in the World is delivered. Furthermore, the company has an established network of over 40 partners throughout more than 60 countries worldwide, ensuring comprehensive support and cooperation wherever our customers are.

"We have used the Fotona Dualis^{XP} Plus and Fidelis^{XS} for almost a year. The results for our clients have been excellent. The learning curve was short, and they are so versatile; we are finding new uses for them each month. Clients who have had procedures done with other systems have commented on how much less discomfort they have had with Fotona's lasers. Fotona's number of years in business, the safety features, the square pulse technology, and the support, were all some of the reasons we chose Fotona. We have not regretted this choice. We would not hesitate to recommend either of these lasers to someone starting a similar practice in hair removal, vein treatments, and skin care." - Mary M. Huff, MD

"I have been working with Fotona Nd:YAG lasers for 6 years now. I started with the Fidelis^{XP}; as my practice grew, to keep up with growing demand, I decided I needed a Dualis^{XP}, then a Dualis^{XP} Plus and finally a DualisVP. I have now performed over 1,800,000 shots without having any problems, and I can say that Fotona laser systems are easy to use and safe. Fotona was my first choice because of their long history in the laser business and their ability to continuously update their range to provide the system performance that I need to be able to give my patients what they expect. I am very satisfied with the Fidelis^{XP} as an introductory system. It allowed me to perform all popular aesthetic laser treatments and the final results were excellent. Once I understood the basic principles of laser/tissue interaction, it was very easy to perform all applications. I am now confident enough to let my nursing staff perform certain treatments under my supervision, allowing us to expand the practice even more. I'd recommend the Fidelis^{XP} to anyone who is looking for new challenges and is eager to expand their practice." - Jasna Blaha MD

"I have been running my laser dental clinic for over 10 years. In the practice we continuously strive to improve our service, knowledge and to offer our patients the latest in dental technologies. With a base of over 3.000 patients, even from neighboring countries, we feel we have achieved something unique. Laser dentistry has played an important role in our success. Lasers are especially effective in improving our patients' comfort levels during procedures, especially when treating sensitive patients. Fotona's laser systems have been instrumental to our success, through their efficiency, versatility and wide range of applications, while meeting the standards a successful and busy laser dentistry practice requires. We recommend the Fidelis Plus II to any colleagues who are seeking to expand their dental practice and embrace the advantages of laser dentistry." - Dr Med Dent, Želimir Božič MSc.

Challenges Facing the Information Society,
the Information and Communication Technology (ICT) Industry, and Iskratel

Franc Dolenc,
Director of Products and Solutions.

By Franc Dolenc

The development of telecommunications over recent decades has followed a fairly unpredictable path. In 1987, Phoenix, Arizona hosted a world telecommunications congress, the International Switching Symposium, with all the great names of that time participating. After an extremely interesting and illuminating technology conference, it was agreed that a group of major visionaries should draw up a document that would predict what telecommunications would look like in 2000, and keep it sealed until the year 2000 actually arrived, when it would then be opened.

In 2000, the event took place in Birmingham, England. We awaited the opening of this 13-year-old prediction with interest and were astonished to discover that in 1987 even the best of the experts had not been able to forecast either the tremendous development of digital mobile telephony or the Internet. This finding brought all the forecasters back down to earth, and we became aware that the development of telecommunications networks is no longer directed by available technology, but rather by sociological change, global trends, new buying habits and, above all, the fact that the thinking of our children will be different from anything we can imagine.

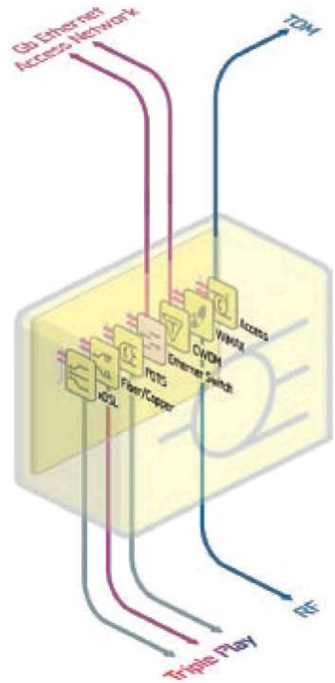
In this dynamic environment we are always keeping an eye on the development of telecommunications or, to put it another way, ICT development, which is the result of the convergence of telecommunications, broadcasting and information technologies. Iskratel is focused on this development in Europe, and in particular in Eastern Europe, which is not only our largest market, but also among the most dynamic markets in the world.

The year 2006 was marked by several turning points. For one thing, the development of conventional digital telecommunications networks virtually stopped. This technology, which was on the rise just a few years ago, is only used to patch holes in the existing network. The British operator, BT, anticipates disconnecting the digital network by the beginning of the next decade. According to most estimates, digital and packet networks will co-exist for some ten years.

Now, 2G (GSM) mobile telephony is spreading rapidly, and mobile subscribers already outnumber fixed subscribers. Mobile telephony is more than just mobility – it also represents the individualization of voice communications. UMTS, i.e. the third generation, is approaching, to be followed by fourth-generation technologies such as WiMAX, WiFi and others.

The development of first-generation broadband networks based on ADSL and ATM technologies has virtually ceased, while the second generation, based on Ethernet, ADSL2+, VDSL and optical technologies, with the full support of triple-play services, i.e. viewing TV and HDTV channels via the telecommunications network, is spreading rapidly. So we are on the brink of the convergence of broadcasting and ICT networks. For the time being this network will mostly be used to broadcast a large number of fixed TV channels, but in a short time we will be able to use video on demand, thus individualizing multimedia content. The required speed of the broadband network will be around a thousand times the speed of the first-generation Internet.

Interactivity and the simple use of multimedia set-top boxes with TV sets will considerably increase the number of users and will also involve those people who do not use personal computers, thus increasing the time that users will spend in a virtual environment. A multimedia set-top box will become as familiar and invisible as a water tap or an electric light bulb. The new infrastructure will radically change education, entertainment, shopping and other areas where people interact. The decade that lies ahead will, therefore, be a decade of new challenges, but not for everyone. In the information era, the digital divide, about which sociologists have already warned us, will stimulate certain nations and social classes to develop faster, while others who are not able to compete will be pushed even further away from the rapid development.



The development of Iskratel is taking place in this dynamic environment. Over the past 10 years Iskratel has been experiencing constant, organic growth. In this period, the company has turned from a fast-follower into a regional innovator. In telecommunications, the globalization process is so rapid that followers no longer exist: a one-year delay results in the loss of customers. Many firms were unable to cover the extremely high development costs, and as a result are no longer present in the market; at the same time a number of smaller companies with innovative products have entered the market. Multinational companies such as Alcatel, Siemens, Ericsson and others underwent drastic changes, too. Under the pressure of a price war triggered by Chinese manufacturers and the struggle for the domination of key

segments of new multimedia telecommunications networks, mergers such as Ericsson-Marconi, Alcatel-Lucent, Siemens-Nokia and others went ahead.

In the face of these changes Iskratel is carefully mapping out its regional and product strategies in order to ensure its survival and growth. Its strategy is based on the development of products that are explicitly tailored to the needs and possibilities of its customers. The countries of Central and Eastern Europe, which is Iskratel's major market, fall into the category of emerging markets. They endeavor to bridge a telecommunications development gap of several decades with ambitious projects, while having an end-user base with a purchasing power several times smaller than developed countries. Owing to these limitations, Iskratel is developing products based on state-of-the-art technology, but still providing outstanding economy in the initial stages of development. During this stage, a low initial price and the largest possible re-use of the existing digital network is required.

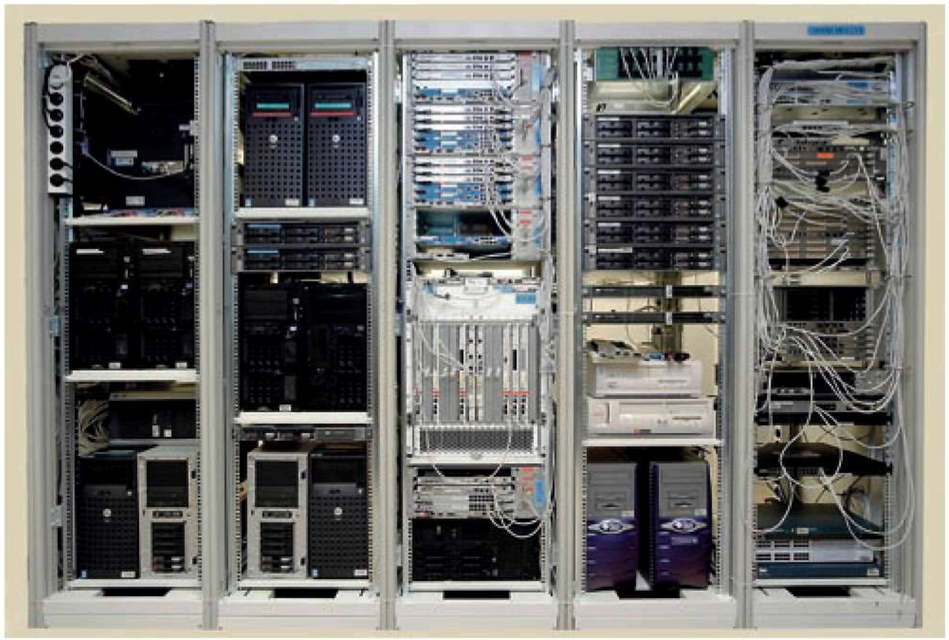
Advanced technology, scalability and connectivity to existing networks are features with which we wish to be at the very top of available solutions, thus becoming a specialist for the evolutionary development of emerging networks.

The requirements of multimedia networks are met with two products: the SI3000 MSAN and the SI3000 MSCN.

The SI3000 MSAN (Multiservice Access Node) was launched on the market about a year ago, and offers a combination of ADSL, VDSL, optical, wireless WiMAX and narrowband connections between users and the network. It connects a variety of interfaces built into diverse cabinets and chassis for indoor and outdoor installation to a uniform, high-capacity Gigabit Ethernet architecture. This approach simplifies the planning of networks. The MSAN is entirely ready for the transmission of data at the extremely high speeds required for IPTV and video-on-demand services, with each user being able to view standard TV channels as well as high-definition channels.

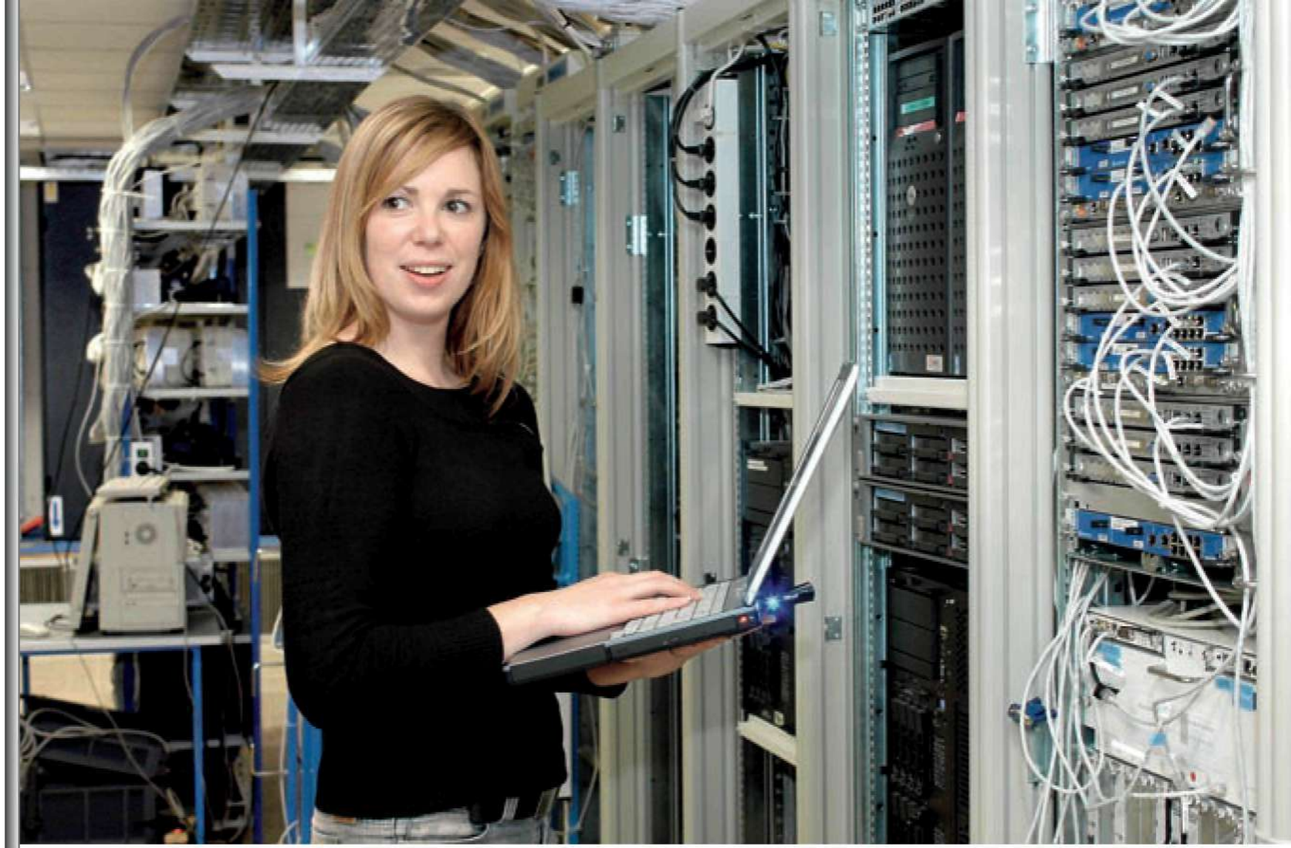
The SI3000 MSCN (Multiservice Control Node) combines the functions of a call server (CS), a media gateway (MG) and an application server (AS). This is an architecture that provides rich functionality both when connected to an existing network as well as on new ports using SIP. The MSCN is moving toward IMS architecture. IMS (IP Multimedia Subsystem) is a unified architecture used to control fixed and mobile networks, and implies the convergence of these networks. IMS has been adopted as the basic strategic and development concept by most operators and equipment vendors.

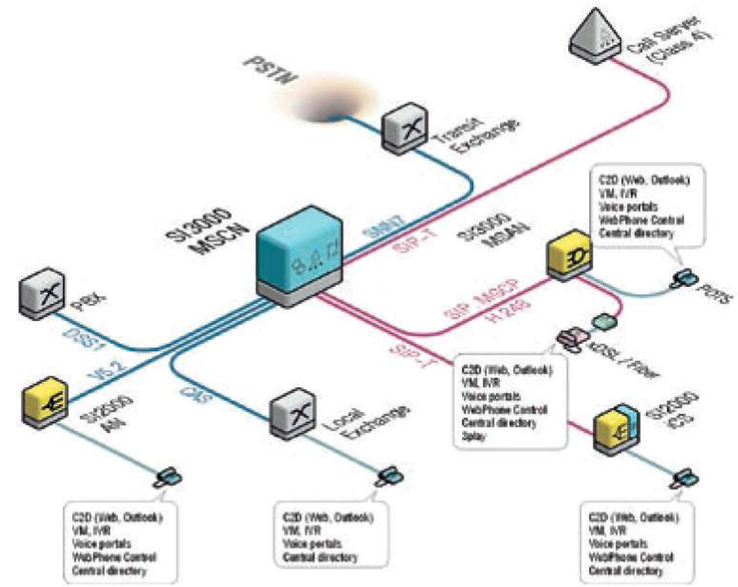
Investing in a single product, the MSCN allows the operator to make several improvements: provide new services to existing subscribers, connect new SIP users, implement an optimal gateway and transition between the two networks, and set up infrastructure for the transition to IMS, when in a few years time this technology matures for mass use.



The SI3000 MSAN and MSCN are interconnected via open interfaces, thus also providing links to products from other manufacturers. Both products are managed by a uniform management node, the SI3000 MN. The SI3000 MN supports the centralized management of several thousand network elements, and several million new telecommunications ports.

The exceptional reliability that telecommunications networks have featured so far is a major challenge facing next-generation products. At Iskratel we pay close attention to this issue. A blend of reliability, flexibility, a variety of functions and exceptional economy are the key advantages that must assure our products a competitive position on a global scale. Iskratel has developed the SI3000 MSAN and MSCN during the past five years, and has invested over 50m of its own funds in the process. The project involves more than 350 of Iskratel's employees as well as several Slovenian research institutions and companies. The staff include experts in the system, application and test software, and hardware and network management, who test the systems in a test center with top-quality equipment, in which nearly 20m has been invested. The staff are constantly aware of the demands placed on them by the uncompromising competition. Most of Iskratel's competitors are multinational companies with a much larger development potential than ours, so we have to focus on product differentiation and the efficiency of our processes. Thus we have returned to the ideas expressed at the beginning of this article. We expect that the unpredictability of the coming decade will reward manufacturers that make decisions quickly and are flexible in adapting to their customers, determined to provide top quality, and innovative when selecting technology and architecture. We are doing our best to concentrate all these features in our small country, and thereby place Slovenia on the global ICT map.





Connecting Slovenian companies, institutions, faculties and other organizations in the field of information and communication technologies

ICT Technology Network

Establishing High-Tech Innovation Convergence

By Andrej Gregorc

Andrej Gregorc

Being born in the late 1970s, I probably belong to one of the last Slovenian generations which still considers itself part of the pre-computer era. My childhood years were mostly spent outdoors, games were played on the street with markings on the pavement and our parents needed to shout through an open window if they figured it was bedtime. Although it was 20 years ago, I can still remember the day I got my first computer. It was the good old ZX Spectrum, with its bulging rubber keys each with a different set of commands. I grew quite fond of my first computer; I remember spending lots of time playing my first-ever computer game – the unforgettable Tetris, which still is a popular game in my "brain gym" even today. I remember the joy of being able to start programming the ZX Spectrum. I quickly mastered the fundamentals of the legendary Basic, and I was able to write simple programmes to count rhythms, to calculate average daytime temperatures, to randomly draw ellipses, to play word trivia, etc. One of the very first routines I put together was about the future – it enabled users to enter their birthdates and the programme returned their age in the year of 2000, the turn of the millennium. For a boy of 8 it was quite a remarkable achievement, one which fascinated me for a long time. Being able to control my computer in such a way that it knew I was going to be 22 when the year 2000 arrived – back in 1986 it opened up a world of the wildest imagination to me. I kept entering my birthdate, checking the results again and again, always drifting away in my reveries about the life and technology we would be using in the unimaginable year 2000. I was daydreaming about tweaking my cordless home telephone so that I could even use it on my longer walks from home. While recovering from a leg injury which kept me in bed for 3 months I realized how practical it would be if we could one day place grocery orders through a computer and order home delivery. Watching the daily congestion during rush hour on major centre-bound city streets, I imagined a system of smart traffic lights which would adapt the green light interval to the direction and quantity of in- or out-bound traffic flow.

My fantasies ended with my childhood, but then came the nineties with their turbulent, rapid and comprehensive technological spin, which grabbed

User-focused Convergence

Janez Bešter is an Associate Professor and Head of the Laboratory for Telecommunications at the Faculty of Electrical Engineering of the University of Ljubljana in Slovenia. His work focuses on planning, realization and management of telecommunication systems and services, implementation and application of information technologies in education, and economic opportunities for knowledge-based societies. He manages different national and international projects, and is also head of the ICT Technology Network project.

Dr Bešter, when and how did the idea for a formation of an ICT network arise?

The idea came from different directions almost simultaneously. Many companies felt the need for such cooperation, the faculties were interested in better and more profound relations with companies, and above all the authorities were also stimulating such a formation. It all began approximately 3 years ago.

Looking at the list of Network members I noticed several groups of companies which are direct competitors to each other. Isn't this a bit unusual?

No, not at all. The Slovenian market is very small and rather limited, and a lost customer is not necessarily lost forever, as the return rate is high. At the same time even competitive companies realize the importance of collaboration, especially in an international environment. So I believe this can be a win-win situation.

Pardon my ignorance, but there seem to be so many forms of cooperation I get lost trying to figure out the difference between them. There are clusters, networks, platforms ...?

Janez Bešter is an Associate Professor and the Head of Laboratory for Telecommunications.

Good observation. This even further underscores the importance of cooperation and connection in the today's technological development. Of course, there are various organizational approaches and grounds for formation of the different entities you mentioned, but cooperation is what they all have in common. Not going too much into details of terminology, I could say the "network" represents the largest and most open form of cooperation, where members are connected horizontally and function as independent entities. Regardless of the form of cooperation, successful projects and results are what matter in today's global environment, so I strongly support any cooperative establishment.

What seems to be the "buzz" word of the current ICT development?

User-focused convergence. Users from all areas of life and work expect and demand easy-to-use devices which integrate all the different functions, services and standards and can be used globally. From the user's point of view, the protocols, hardware and software needed in the background to make it all happen are not important. In the not-so-distant past, technology was at the centre of the model and users needed to adapt to it. This has changed – now we are building and adjusting the technology around the user.

Do you ever get the feeling that life has become too technical? Is the good old-fashioned way gone forever?

Technology certainly has had a drastic influence on how we live, work and even spend our spare time, but I see this influence as a positive and helpful one; however, we must not forget that all of these devices also have an "off" button, but they are there and available when we need them.

Where do you as the project head see the key advantage and opportunity of the ICT Technology Network?

Proverbial Slovenian inventiveness and adaptability are the characteristics which can add the decisive factor on our behalf. All of the activities which the Network has undertaken could culminate in a Technology Design Centre – a visionary approach to integration of interdisciplinary knowledge, multi-media technologies and high-tech entrepreneurship.

Technology Network ICT Members

- Alpineon, Ljubljana
- Amoebius, Ljubljana
- Cetis, Celje
- Cosylab, Ljubljana
- Elti, Gornja Radgona
- Eurocon, Ljubljana
- Health Insurance Institute of Slovenia, Ljubljana
- Hermes Softlab, Ljubljana
- IAM Inštitut in akademija za multimedije, Ljubljana
- IBM Slovenia, Ljubljana
- Infonet, Kranj
- Infos, Ljubljana
- Institute for Economic Research, Ljubljana
- Intekom, Ljubljana
- IPMIT, Ljubljana
- IPS, Ljubljana
- Iskra sistemi, Ljubljana
- Iskra zaščite, Ljubljana
- Iskraemeco, Kranj
- Iskratel Electronics, Kranj
- Iskratel, Kranj
- Iskrateling, Kranj
- Jožef Stefan Institute, Ljubljana
- Marand, Ljubljana
- Medius, Ljubljana
- MG-Soft, Maribor
- Microsoft Slovenija, Ljubljana
- MKS Elektronski sistemi, Ljubljana
- Mobitel, Ljubljana
- Perftech, Bled
- Pristop, Ljubljana
- Radiotelevizija Slovenija, Ljubljana
- RAP-ing, Ljubljana
- Razvojni center IRC Celje, Celje
- SETCCE, Ljubljana
- SiMobil, Ljubljana
- Siol, Ljubljana
- SmartCom, Ljubljana
- SRC.SI, Ljubljana
- Telekom Slovenije, Ljubljana
- TSE, Ljubljana
- University of Ljubljana: Faculty of Electrical Engineering
- University of Ljubljana: Faculty of Computer and Information Science
- University of Maribor: Faculty of Electrical Engineering and Computer Science

Slovenia Technology Network ICT Facts
Founded: 2003
Members: 42 +
Workforce of member companies: 17,000 +
Total income: 1.7 billion EUR (2005)
Export share: 27% (2005)
Webpage: www.ict-slovenia.net

Dr Peter Stanovnik, Institute for Economic Research:
"A high level of ICT development and technology use among the population can contribute significantly to the overall welfare of the nation. Joint projects, cooperation and different forms of connections among companies within the national economy and internationally can stimulate and spur innovation and exchange of knowledge even further."

Kristl Ogris, Perftech:
"Over 100 experts from different fields of ICT who work together at Perftech provide high-quality and efficient information and communications solutions for our customers. High team spirit, specific skills and knowledge, combined with local and international partnerships, are our strategic advantages."

Marko Bohanec, Microsoft Slovenija:
"Microsoft Slovenija has always been focused on forging close relationships and partnerships with information and communications technology companies as well as government, non-governmental and academic institutions in Slovenia. In a time of globalisation and the challenges it brings, ICT and such partnerships are key for establishing an environment that fosters innovation, rewards risk-taking and helps Slovenia to become a knowledge-based economy."

the society and brought about unprecedented new dimensions. Some of my childhood fantasies revived as I started witnessing the endless possibilities of technology.
Today, half a decade after the year 2000, it seems the whirlwind of technology has not yet stopped. Moreover, it has penetrated into almost every aspect of our lives and has become a major if not the determining factor of quality of life and the development of society. Since the time we biologically separated from monkeys, humans have gone through an array of evolutionary phases, from hunting and gathering to the information society. Each of the steps in evolution was named for the primary factor which influenced or still influences the behaviour and the functioning of the society. Many things have changed since the Stone Age, but one critical element for the survival of society remains – access to information and the ability to do something with it. The whereabouts of mammoths and hunting know-how were as important millennia ago as state-of-the-art technologies and services are today. It is therefore no wonder that the most recent evolutionary phase was named the "information society", even better known as the "knowledge society".
Slovenia has had its share of success in many areas since declaring independence in 1991. In the last 15 years Slovenia has successfully completed its economic transition, stabilized its monetary system, joined several international organizations and strengthened its position in global technological research and development. Slovenian companies in the field of ICT (information and communication technology) have always been among the world's most recognizable and respected producers of products, equipment, solutions and services. Slovenia is not only one of the few countries on the globe which are capable of their own development, production and implementation of advanced information and telecommunication systems and services, but is in many fields the "top dog" of the industry. With the political changes in Central and Eastern Europe, Slovenia's geostrategic location was even further enhanced. Being located at the crossroads of **two major European traffic corridors**, at the **meeting point of four large geographic macro regions** and at the **gateway between the East and the West** brings many additional advantages besides excellent logistics opportunities. Not only can the region function as a major

Franc Dolenc, Iskratel:
"Our company's basic activity is the development of complete solutions for fixed and mobile telephony, convergence networks, next-generation networks and the network management required for the communication needs of the future information society. Participating in the various projects of the ICT technology network provides additional synergistic effects and expands our markets."

Domen Rakovec, Mobitel:
"We have successfully implemented three generations of mobile telecommunications in the past 15 years. Maintaining high competitiveness and keeping pace with swift development can only happen in good cooperation with service providers, research companies and other partners within the network."

shipping corridor, but it can also be an excellent example of a **trans-national ICT-powered e-region** encompassing the research centres and facilities of the neighbouring countries with the aim of providing technological support for contemporary Europe.
Increased competition among equipment suppliers and operators has influenced the dramatic decrease of communication costs over the last few years. Developing new applications and services further increases the widespread use of information and telecommunication technologies. Coinciding with the massive increase in the use of ICT is the **process of convergence**, which stimulates different devices, standards and protocols to merge and integrate. Computers, household appliances, automobile electronics, photo equipment, machines and other devices culminate in connected units which interact with each other, share and exchange data and communicate. Due to converging development, information and communication technologies represent a crucial platform for future solutions and progressive projects for modern economies, enterprises and households. The convergent development of services and systems is also reflected in the managing and functioning of successful enterprises. In order to bring a research solution into production and widespread use, cooperation and communication between the social, natural and physical sciences, engineering, different economic sectors and education are compulsory.
Following the basic technological trends of connecting and converging Slovenian companies, various institutions, faculties and other organizations in the largest context of ICT formed a technology network in 2003 with the aim of **efficient technological synergy**. The Slovenian ICT Technology Network is establishing links between networks and technologies, individuals and organizations, skills and solutions, content and services, users and providers. Based on individual projects, top-level knowledge and capabilities for research and development, the Technology Network enables and facilitates a creative and inventive environment for upcoming strategic challenges. The network excels in its own research and development, knowledge meeting points, a high-level standard of ICT and dynamic enterprises. Many of its member companies have a long tradition in manufacturing and marketing ICT products, systems and services on the global market. The Slovenian market, with just two million inhabitants, is very demanding and gives swift results for whether a particular product or service can survive its launch phase. All of these advantages constitute an excellent basis for the establishment of an international ICT test centre in Slovenia which could stimulate formation of new companies and joint ventures.
The ICT Technology Network defined different fields of research for breakthrough solutions and results. These can be generally categorized into:

- Seamless User Experience
- Service Environment
- Transport Networks
- Security and Trust
- Multimedia Content

In the few years since its inception, the Technology Network has created new research teams with participants from different companies who have carried out several important projects, includ-

Daniel Copot, Elti:
"We listen to our partners in 40 countries around the world, and we provide a wide range of products and services for the broadcasting communications market. We celebrated our 50th anniversary last year and have set ambitious goals for the next phase of the digital era. As our slogan "birds of feather fly together" says, we believe in strong cooperation with our partners and the local environment."

Andrej Jus, Infos:
"The achievements and products in the field of ICT network technology comprise a substantial part of Hevreka!, the annual technology R&D event which we organize in Ljubljana in October."

Dr Jerneja Gros, Alpineon:
"The Alpineon industrial R&D group provides turnkey software and hardware solutions in the ICT, automotive and industrial automation control fields, with an emphasis on speech technologies products and services. Our team has extensive experience in hardware and software development – we have everything that is needed to quickly and effectively satisfy our customers' demands: people, knowledge, equipment and experience. Alpineon continues the cooperation the coimpany has established with major industrial players, academic institutions and other research organizations."

Dr Jadran Lenarčič, Jožef Stefan Institute:
"The Jožef Stefan Institute is the biggest public research institute in Slovenia. About 800 people are employed in the main research areas of physics, chemistry, molecular biology and biotechnology, information technologies, reactor physics and technology, energy and the environment. Our mission is the accumulation and dissemination of knowledge, particularly in close collaboration with Slovenian and international companies and similar institutes."

ing SINTESIO, Centre of Excellence, Electronic Fee Collection for Free-Flowing Traffic, IP TV, intelligent and safe home and intelligent office, multimedia blended e-learning incorporated into life-long education, comprehensive systems for energy management and distribution, telemedicine and e-health services, and multi-service access nodes.

SINTESIO (www.sintesio.org) is an open, non-profit NGN interoperability test laboratory, endorsed by the European Telecommunication Standardization Institute (ETSI) and co-founded by industry partners, standardization institutions and universities. In close cooperation with standardization bodies such as ETSI PTCC, ETSI TISPAN WG6, IETF and ITU-T, the SINTESIO project provides equipment vendors, research groups and institutes with an exchange of testing results and opinions. One of the main tasks of SINTESIO is to organize and execute interoperability events, with special emphasis on structured and well-prepared test standards, test methodology and reporting to participants and standardization bodies. It will also organize and execute workshops, seminars and tutorials on subjects of interoperability and test methodology. SINTESIO will develop a proposal to establish a technology platform that will connect other testing laboratories specialized in interoperability testing. SINTESIO is supported by the Ministry of the Economy / DG for Electronic Communications, and the Ministry of Higher Education, Science and Technology / DG for the Information Society.

The Centre of Excellence for information and communication technologies and services established a partnership connection between institutions and enterprises that are trying to generate and integrate technical, applied, innovative, evolutionary and research excellence in the broader multidisciplinary field of information and communication technologies and services. The networking of a critical mass of experts and knowledge is directed towards joint integrated projects for partners, with real market possibilities. Larger investments in intellectual capital enable a new way of partnership cooperation, better adapted to the challenges of present-day research. Currently, there are six different ongoing projects:

- Technologies for education and development of innovative environments (co-ordinated by the Faculty of Electrical Engineering, Ljubljana)
- Voice and graphic technologies in information and communication technologies (co-ordinated by the Faculty of Electrical Engineering and Computer Science, Maribor)
- Command of research process and information technologies in developing solutions for electronic business (co-ordinated by the Faculty of Computer and Information Science, Ljubljana)
- Protocols and integration of services in convergent systems of NGN (co-ordinated by the Faculty of Electrical Engineering, Ljubljana)
- Wireless communication platforms (co-ordinated by the Jožef Stefan Institute, Ljubljana)
- Verification of the regularity of operation of communication systems (co-ordinated by the Faculty of Electrical Engineering and Computer Science, Maribor)

The Centre of Excellence is supported by the Ministry of Higher Education, Science and Technology.

The project **Electronic Fee Collection for Free-Flowing Traffic** (www.e-cestninjenje.si) is the result of cooperation between Slovenian companies, universities and a national mobile telecommunications operator. Using the latest telecommunication and information technologies the project resulted in a prototype solution that works on all highways in Slovenia. The results proved that with a satellite-based EFC system governments may be able intro-

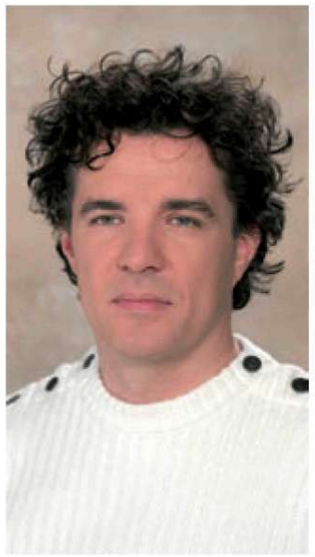
Dr Marjan Heričko, Faculty of Electrical Engineering and Computer Science, University of Maribor:
"Alongside its educational role, our faculty is deeply involved in research, development and projects with Slovenian companies. A high level of cooperation with industry is necessary in order to understand and track the needs of the ICT market, to establish efficient knowledge management and to adequately prepare our students for the most demanding jobs in the collaborative environment.

Dr Andrej Duh, MG-SOFT:
"MG-SOFT provides major IT companies worldwide with network management applications as well as with toolkits implementing core network management technologies. Furthermore, MG-SOFT provides customers with consulting services, custom software development services and network management integration solutions based on our extensive experience in the SNMP, SMI and network management fields."

Miro Štravs, Smart Com:
"Smart Com is a high technology company specialising in system integration and the development of systems used for electronic communications. Smart Com provides consultancy, design, supply, integration, maintenance and support to operation services for communication systems for our customers.
We adhere to our product strategy in realizing the company vision and meeting the needs and expectations of three customer groups: utility companies, telecommunications service providers and businesses. The competitive advantage of Smart Com is based on interdisciplinary knowledge covering customer processes, services, networking and telecommunication technologies. The focus of Smart Com and company strength is based on end-to-end, broadband, all-IP communication solutions and service centre solutions for converged data, voice and video services.
By cooperating with the most prominent representatives – organisations within industry – we maintain permanent contact with the development of their information requirements and thus give added value to our tailor-made solutions."

Tomaž Gornik, Marand:
"As the leading Slovenian company in the field of IT consulting, system integration, development, implementation and support of complex hardware and software systems for multi-site environments, Marand is establishing a global network of partnerships with leading international system integrators and technical consultants as well as providers of complementary hardware and software products."

Aleksej Jerman Blažič, SETCCE:
"The Security Technology Competence Centre is an association of organizations for research, development and technology transfer in the area of security technology and electronic business. Strong relationships with distinguished international partners help us transfer knowledge and experience from the field of research directly into industry."



Zvezdan Martič, Radiotelevizija Slovenija:
"Following EBU guidelines, RTV Slovenija is transforming from a monomedia into a multimedia organization. The cutting-edge technology multimedia centre established in 2001 is the first step in this transformation and enables the exchange of digital content with our partners and other European broadcasting companies."

Once a month, the user receives an invoice for road tolls and other services enabled on the user's OBU.

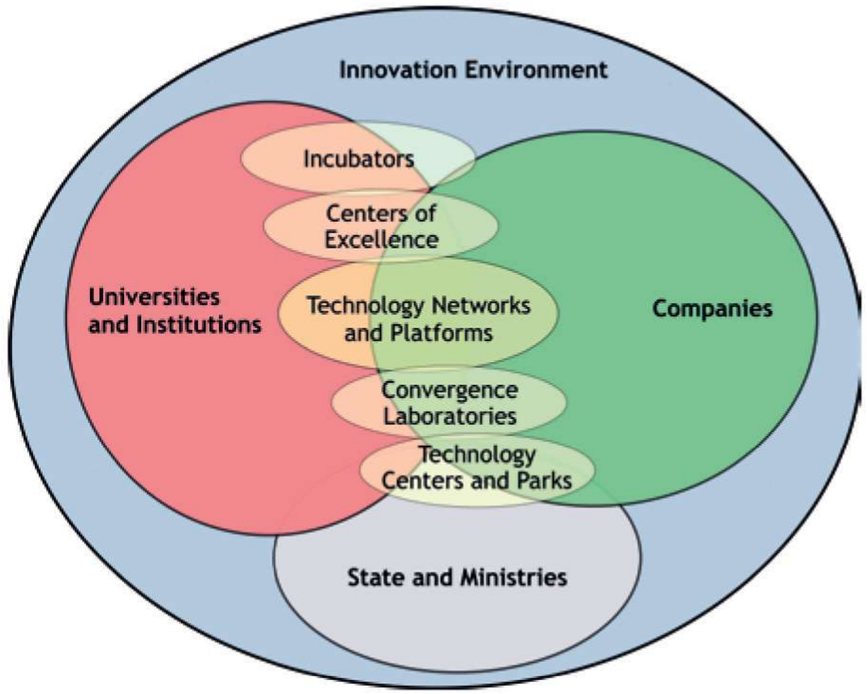
Members of ICT Technology Network started an **E-Health** project, the main goal of which is to provide healthcare via electronic means, in particular over the Internet. The term e-health has been used to describe a variety of activities related to the electronic exchange of health-related data, voice and video. The E-Health project is supported by the Ministry of Higher Education, Science and Technology / DG for the Information Society.

Intelligent home and office are the basic concepts of the so-called **Connected** project. The partners involved created a pilot project for safe and intelligent buildings and demo rooms with the goal of setting up innovative environments: homes and offices of the future.

The **Multimedia Blended E-Learning** project, incorporated into life-long education, covers all aspects of e-learning: development of an e-learning platform and implementation in a real-life environment, the creation of multimedia content for e-learning, with emphasis on using and incorporating modern techniques for easier and more efficient learning for all age groups and target audiences.

Members of the ICT Technology Network are also working on a project for **IP and Mobile TV**, developing Internet-protocol television. This is a system where digital television service (DVB) is delivered to subscribers using an Internet protocol over a broadband connection in conjunction with video-on-demand and inclusion of Internet services such as web access and VoIP. Establishing a pilot mobile TV which will enable end users to enjoy on-the-air TV and radio programmes is another project strategy.

Multi-media Access Node is based on the concept of "NGN universal point of presence" on account of its optional combinations of functional elements at peripheral positions. The concept allows the installation of "pure" NGN networks as well as operation in a convergent network environment. Multimedia access points can be used for connecting TDM access nodes to soft switches via various protocols and interfaces. The multi-media access node architecture, software and hardware have been optimized for the implementation of broadcasting/multicasting technologies with the IGMP protocol if used as a node for IPDSLAM broadband access and optical broadband access using FTTx technologies.



Many other ICT Technology Network projects have commenced and are all part of the strategy for the Network's development and evolution. The Slovenian ICT Technology Network is also working closely with other similar technology networks in Slovenia and forms a **consortium of Slovenian technology networks.** Members of the Technology Network have also initiated different Slovenian **technology platforms**, organized in accordance with homonymous European technology platforms**:**

- **eMobility** (The Mobile and Wireless Communications Technology Platform)
- **ARTEMIS** (Embedded Systems)
- **NEM Initiative** (European Initiative on Networked and Electronic Media)
- **NESSI** (Networked European Software and Services Initiative)

The carousel of progress in ICT keeps going round, and its pace is sometimes difficult to comprehend, follow and cope with. The bold visions I had as a boy, which I mentioned in the beginning of this article, are now already fading into technological history. Is it at all possible nowadays to envision the products, services and technologies we will be using in three or four decades? It is a tough job and the stakes are high! The ability to forecast the way development will swing means the difference between being on top and just following along. It seems the members of the ICT Technology Network are determined not to be among the latter, but will continue to actively participate in technological trend-setting and play a key role in the promise of a technological tomorrow.

podčlanek v večjem okvirju

IBM Transfers Best Business Practices to Slovenian Industry

By Boris Čerin

IBM Slovenia has been operating successful for 13 years now, and at the beginning of this year the leadership of the company was handed over to the new managing director of IBM Slovenia and the Countries of South Eastern region, Biljana Weber, who gained the title of MBA after post-graduate studies in Britain. She has begun her career at IBM 13 years ago, entering management in 1996 as head of the Personal Computers Unit, after which she performed various management functions at IBM Slovenia. Then she worked for five years in Vienna, the last two as head of marketing for IBM Central and Eastern Europe, the Middle East, Africa (CEMA). In conversation with her it was clear to me that she is an excellent manager with a range of experience in the area of international sales channels, in business development and in marketing leadership. She has also proven herself through her ability to build networks of business partners and through excellent cooperation with the top managers of IBM's clients. She is also the first woman CEO of IBM Slovenia, and one of the rare female CEOs of major IT companies in Europe.

Quark: How would you compare your work in Vienna with your new duties in Ljubljana?

Working in the management of a regional organization enables a person to recognise the wider aspects of how a global enterprise operates, and in contacts with the managers of subsidiaries in various countries to compare the similarities and differences in the way they operate. In this respect the CEMA region is exceptionally interesting – on the one hand it is a region with one of the highest growth rates in the whole of IBM, while on the other hand operations are relatively complicated owing to the profusion of countries (39), languages (21), cultures, religions ... My new responsibilities present me with new challenges and opportunities – I am especially pleased that I will once again be in direct daily contact with our clients and business partners – after a few years of more strategic and corporate work on the regional level, a person likes to get back to more daily contacts with the everyday market pulse. I believe that together with the management team of IBM Slovenia and South East area I can contribute even more successfuly to the transfer of IBM's global knowledge and experience to our environment, something that will be reflected in the commercial success and increased satisfaction of our clients, and ultimately in the good business performance of IBM Slovenia and South East area.

Quark: What are the main tasks of IBM Slovenia?

The main area of work for IBM Slovenia is still the sale and support of the highest quality information technology.

Director of IBM Slovenia and the Countries of South Eastern Europe, Biljana Weber.

Like everywhere else in the world, in Slovenia alongside the classical sale of hardware and software, services are becoming increasingly important. In addition to services that are closely connected to IBM products – such as the design, installation and maintenance of our IT systems – business consultancy services are becoming increasingly important, and following the acquisition of the consultancy firm Price Waterhouse Coopers Consulting, IBM is now one of the leading world providers of this service. IBM can therefore offer the transfer of the best business practices from the most progressive global environments to Slovenia's economy and administration. This involves numerous conceptual approaches for optimising operations in various sectors, process and data models, methodologies of introducing changes ... In a world where speed of adaptation and change is becoming one of the primary requirements for operating, familiarity with and use of such solutions can be one of the key factors for the success of our clients. Although such solutions are not cheap, it is already generally accepted around the world that learning from one's own mistakes is much more expensive and often enough even fatal, and above all too slow ... Of course from the international aspect IBM Slovenia can boost a strong team of around 60 experts, who work at the Ljubljana competence centre, from where they ensure support for number of IBM products for the whole of Europe. IBM Slovenia thus ranks among the major exporters of Slovenian skills and expertise.

Quark: What is the role of IBM's business partners?

IBM devotes great attention to cooperation with business partners. Through its own sales and service organisation IBM can only cover a portion of its potential clients, mainly the large organizations. So a large proportion of the market is covered directly or independently by our business partners, where of course we pay close attention to their high professional ability and generally to their operations, which must ensure the highest possible client satisfaction. IBM's model of cooperation with business partners is designed for the long term, and requires on both sides a great amount of diligence and

... Of course from the international aspect IBM Slovenia can boast a strong team of around 60 experts, who work at the Ljubljana competence centre, from where they ensure support for certain IBM products for the whole of Europe.

investments but it provides for certified business partners in addition to the top IBM technologies at favourable prices IBM's support in any kind of difficulty, which is very important for the end user. In Slovenia, too, we have a growing number of business partners who are aware that for a long-term successful business model, which must be based on clients satisfaction, it is also important to have qualified and professional personnel of the highest quality.

Quark: Three years ago IBM introduced the concept of "E-business on demand". How are you establishing this in Slovenia?

E-business on demand involves a long-term conceptual approach into which IBM is gradually incorporating all its products and services. The basic concept is quite simple: we wish to help our clients set up and provide IT support for the kinds of integrated business processes within their organisations and with their business partners, suppliers and customers that will enable them to respond flexibly and rapidly to any kind of demand from their customers, to market opportunities or external threats. In the future, therefore, the development of information technology should head in the direction that we are already used to in electricity supply – always available to clients, you pay for it by use, and the technical details of the power supply system in the background are of no interest to any of users. In Slovenia the idea of e-business on demand is for the moment being established primarily on the level of individual technical solutions. But some Slovenian organizations are also starting to realize that IT is not their main business, and they are starting to think about possible optimizations, so we are gradually anticipating greater demand for complex solutions.

The automated interoperability of different partner's information systems is no longer science fiction. A service-oriented architecture enables companies to execute their internal and external business processes without human intervention.

Electronic Commerce

By Boris Čerin

In the beginning, only individual business functions were provided with computers, and therefore efficiency of administration work could not be increased. Further development of information and telecommunication technologies enabled automated execution of those functions into connected internal business processes. The next step was connecting processes within organizations and between partners. Nowadays the connection of internal and external business processes is one of the most challenging objectives for companies, banks, insurance companies, government agencies and customs administrations. At the same time they implement paperless business environments which result in rapid growth of electronic document and data interchange. The features and approaches of service-oriented technologies ensure fast implementation of electronic commerce benefits for everyday working activities.

QUARK: Has your company specialized in the development of centralized information systems?

ZORKO: Yes, it all started at the beginning of the nineties, when Slovenia gained its independence. At that time many changes in the approaches to development of information technologies occurred. We strongly believed in the benefits of centralized and connected information systems despite mainstream technology being directed towards distributed and heterogeneous environments. Once again, connecting and consolidating systems became popular. Service-oriented architecture revives those effective traditions for business computing support. Our development of customized systems, for example, includes development of information systems for Customs Administration. For that reason we have put a lot of our effort into change management to be efficient enough when implementing legislative data, documentation and processes.

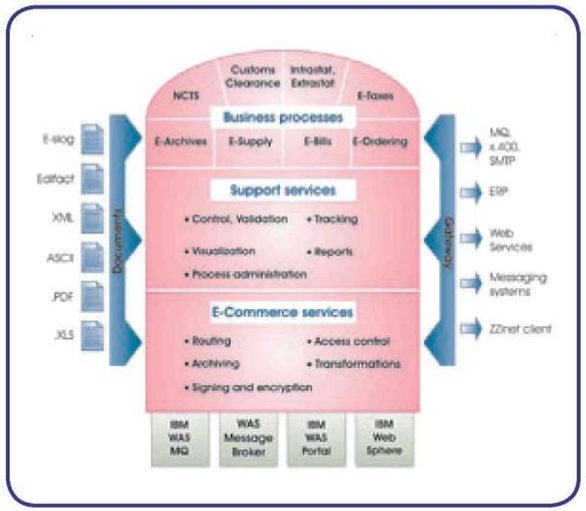
QUARK: Why e-commerce?

ZORKO: For organizations which collaborate with numerous partners and process many documents on a daily basis, electronic commerce is the only solution. We can compare the influence of e-commerce on business performance with the introduction of the internal combustion engine or electric engine. Systems for automated document exchange enable process execution without human participation. The savings in working hours are enormous. Thus employees can perform their tasks effectively and on time, and in addition be incorporated into other activities which generate added value.

The Slovenian Customs Administration implemented an electronic data interchange in 1996. In the next four years, by the year 2000, they achieved a 98 percent record of customs declarations entered electronically. That resulted in elimination of manual work, minimization of mistakes made during document data entry and gaining speed in customs processes. The whole custom process was automated, including application forms, paying custom fees and releasing goods.

QUARK: Why do you think that companies should execute e-commerce with government agencies using service providers?

ZORKO: We are convinced that outsourced providers offer the best solutions for electronic commerce with government agencies. Furthermore, solution providers ensure quality customer support and adjustment to legislation. They provide government agencies with inexpensive systems for e-commerce and high-quality services for end users. As experts in system integration and e-commerce, we made a commitment to offer the best solutions at an attractive price. Moreover, our customers don't have to invest in expensive expansion of their IT infrastructure. They manage information exchange within electronic business processes over client software which is free of charge! Our customers exchange electronic documents with any partner for a fee of 10 tolars, or 4 euro cents, per document.



Partners can use ZZInet services with different protocols and document formats in a unified and reliable way.

The expansion of e-commerce in Slovenia has been strengthened by the quality work of our customer support team. In the last two years we gained over 100 new customers who have been using our electronic document exchange regardless of their legacy IT solutions and systems. Another benefit is represented by using the most advanced infrastructure for the lowest price, which is only possible because the provider's investments are dispersed. Exchange services, document cycling through a business process, transformations and services for monitoring and managing must be reliable, while appropriate data and privacy protection must be provided – including archiving. We decided to invest in technology because we wanted to achieve a short time to market and ensure high quality. The technology platform of our e-commerce solutions is the Service Oriented Architecture (SOA). We have been using IBM software solutions which provide us with solid technology pillars and possibilities for immediate response to our customers and market demands.

In the same manner, companies essentially shorten the time it takes to make use of e-commerce services by employing outsourced services and can then devote attention to improvements of core business and performance quality.

Foreign trading services, such as simplified customs procedures include electronically entered declarations, acceptance confirmation on the Customs Administration side, notification for release of goods or inspection, payment liabilities and issuing accounting data.

The entire procedure, from entering declaration to releasing goods, is automated without goods being retained. Our solutions support other business processes such as European NTCS transit procedures, e-procurement and e-supplying in merchandising, Intrastat reporting, exchange of electronic invoices, maintaining registries, electronic tax reporting and so on.

It is essential for processes to act automatically, so the application begins and ends the procedure on its own without human intervention. Therefore the reliability of such systems is crucial, including distribution of instant messages to pre-set addresses in case of malfunctions.

QUARK: Is it necessary to unify the standards which organize documents, procedures and means of transport to achieve simple application and system integration?

ZORKO: Modern approaches to development of information solutions are founded on demands for simple adaptation and integration of business processes. The answer is service-oriented infrastructure (SOA), which emphasizes design of independent components and functions integrated with standard services rather than composing program code into heavy applications. IT infrastructure vendors have recognized the need for reconciliation of integration methods and the opportunity to define those methods upon broadly accepted standards. The approaches or styles of presentation, usage of services and means of transport have been standardized, rather than technologies or applications. It is necessary to have sophisticated technologies and the promise of continual adaptation to changing market conditions, if you want to successfully manage a system which embraces integration and distribution of data and claims. The transition of IBM's system of managing messages and processes has essentially improved and mitigated our work.

Igor Zorko, Director.

QUARK: Who were the first adopters of your services?

ZORKO: Since 1996 when the Customs Administration started to use electronic commerce and after that in the year 2000, when it introduced independent electronic submission of simplified customs procedures. The majority of importers, exporters and logistics companies use these services. They ensure comprehensive electronic commerce between the Customs Administration and manufacturers, merchants and logistics companies. The Slovene Customs Administration has always been open to new technological initiatives. In this way we contributed to shortening the queues in front of customs offices, or at the state border.

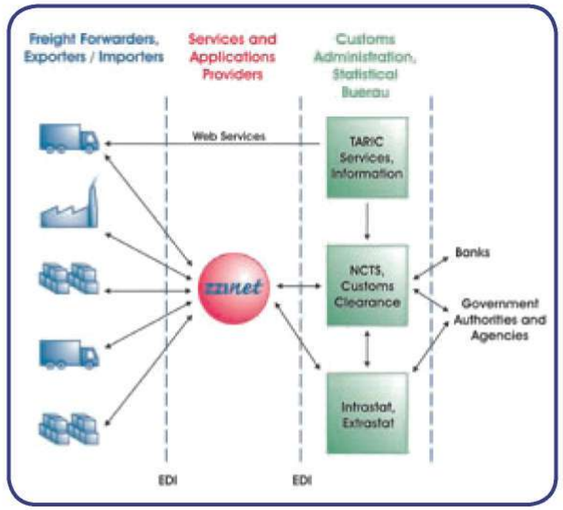
We released ZZInet services and other proprietary software products for foreign trade regulatory affairs in the year 2000. Some domestic companies, with numerous different procedures that incorporate a lot of documents, quickly took advantage of these electronic services. For example, companies such as Gorenje, Lek, Iskraemeco, Lama Dekani, LIV Postojna, Radenska, Tehnounion, and ACRONI Jesenice. Today, over 400 companies with an aggregate of more than 6 million documents per year use ZZInet services. Companies are aware of the high costs of setting up a system for electronic exchange with many partners. It is also irrational to compare prices with outsourced services. They would also need to establish customer support services and integrate the parties involved in e-commerce. Can you imagine every large Slovene company as a mobile phone operator? On the other hand, demands for integration of internal applications and systems into services, which are levelled with business requirements, are growing rapidly.

All organizations lean towards establishing new ways of information exchange and document transformation. Banks have been linking up and connecting with their customers and government agencies. Their e-commerce includes payment operations, ordering financial services and other procedures such as monitoring customer credits between banks, trading between banks and reporting to the Bank of Slovenia, Tax Administration and other agencies. We all wish for such procedures to be fulfilled immediately; this is only possible with seamless integration between the parties involved. Insurance companies also exchange information and data in a similar way. The most important consideration is for the system to ensure independence of

the different connected systems, but which still acts as one.

QUARK: Can you highlight such an example?

ZORKO: It's quite simple. It could be the company which has bought, let me say, an information system, application for financial management or perhaps a manufacturing subsystem. Such a system has very limited possibilities for integrating with partners or even for collaboration within internal processes. Difficulties cannot usually be avoided even if partners eliminate manual procedures such as ordering or accounting. For that reason, the company has to ensure appropriate means of communication, document types and structures, and availability of all necessary data. The *de facto* standards for electronic exchange in most developed countries are EDIfact documents transmitted over an X.400 transport connection. Slovenian companies have adopted E-slog XML messaging as the national standard, which is a more simple and understandable format than EDIfact, and web services using SOAP as the transport. One concrete example is the Elektromaterial company. One of their biggest customers, Bahag of Germany, informed them about the need to move to electronic commerce in order to reduce its operating costs. Bahag demanded the same from its suppliers and started to charge for paper-based trading. As service providers for the exchange and transformation of information, ZZI has been capturing data from Elektromaterial's information system into E-slog XML files, conversion from E-slog format into EDIfact format and transmission of those standard documents into Bahag's communication network. Even if it sounds simple, rearrangement was very complicated because documents and communication at the partner's side were based on completely different standards. Nevertheless, we provided our customer with a quality solution in just one month, so they implemented their partner's demands in the timeframe required.



Ensuring end-to-end support for foreign trading while connecting different systems (connections B2B and B2G).

QUARK: It all works automatically, without human intervention?

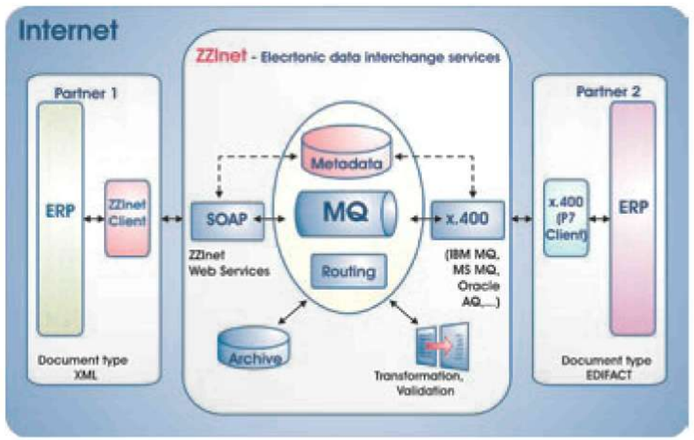
ZORKO: Of course. We can execute transcription and transmission in both directions regardless of the original document standards, which could be different. SOA services enable companies to organize their data and information system in the most convenient manner, without requiring them to accommodate partners' requests. They do have to provide us with the data which their partners demand, but it is not necessary that the data be in standard form.

But the best thing is that the initial costs for our customers are zero. If companies have at least some standardized documents, the cost of document conversion is ours. We only charge for conversion if the documents are completely for internal use and developed without any available standards, so we need to design some software add-ons to receive their data. Fortunately, we have the most sophisticated development tools and highly qualified experts, so we can ensure conversion in only one or two days. We charge for service usage according to the number of performed exchanges.

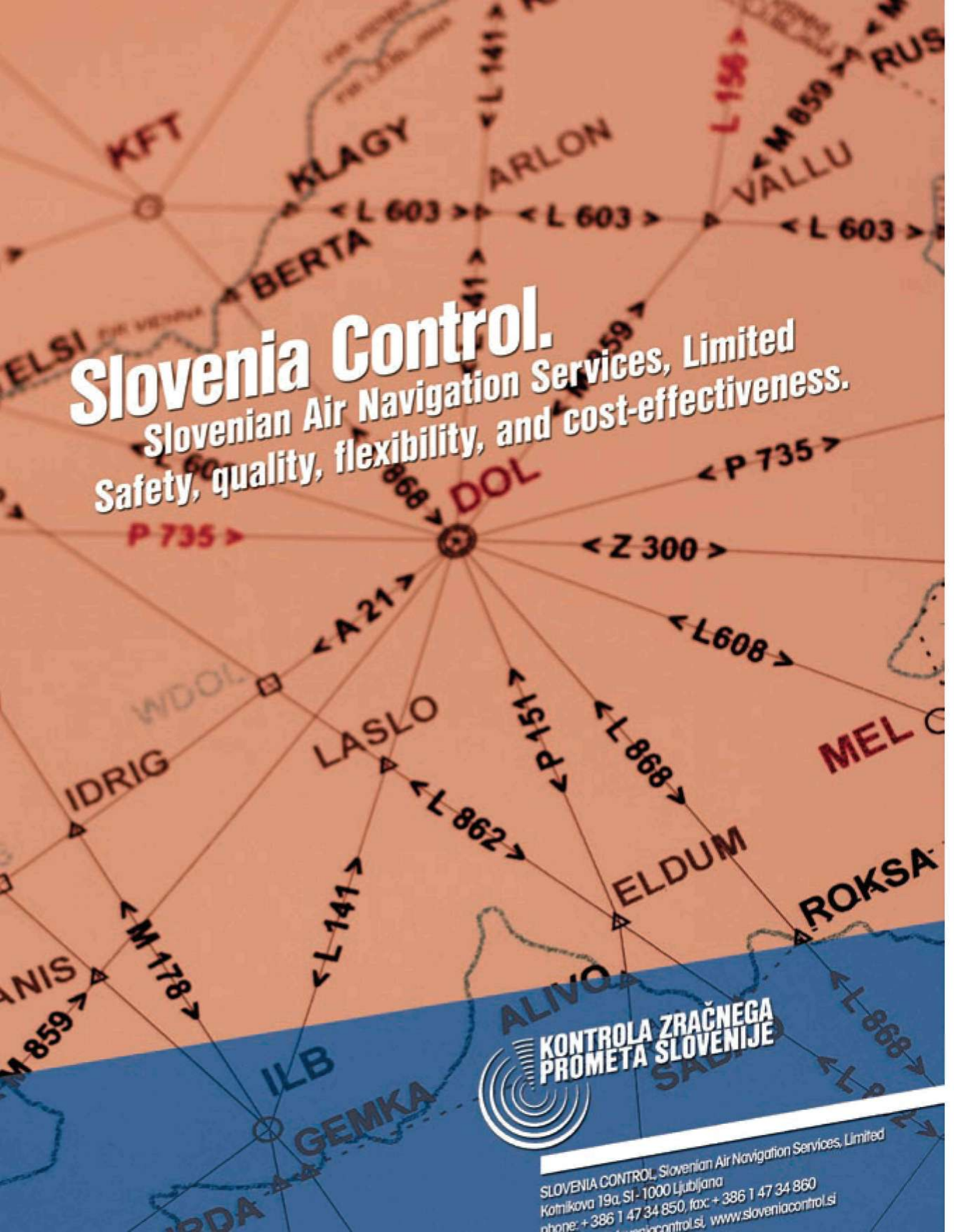
It sounds easy, but it's not. We must define the whole business process, from entering the document into our network and then leaving, and ensure tracking of this document across the entire system. The services, tracking and all performed tasks become part of the customer's information system, and this is the way that we create automation.

QUARK: Finally, what is your vision of e-commerce?

ZORKO: I believe that e-commerce means better business process performance and total quality of business execution with lower operating costs. That is why we have broadened our e-business services this autumn with a new archiving service, eHramba.si. The service is based on the IBM Content Manager and is designed for automated, permanent storage of electronic documents directly from business processes. We can integrate the service with backoffice systems, business applications and services. As eHramba.si is available as a service, it relieves customers of the burden of high initial investments and regulatory risks. Users are relieved of additional tasks and costs concerning ownership and management of infrastructure. eHramba.si, together with the rest of our services and solutions, represents the most convenient and cost effective way to complete e-business – totally paperless.



An example of automated transformation within the ZZInet service.



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