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In this issue

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A global village?

*Information and communication technologies
have redefined traditional concepts of proximity,
creating vast communities where distances are
short and response times are rapid. A global
village, we are told — although the actual
inhabitants are just as likely to live in cities. United
Nations estimates suggest that more than half of the
world's population is now living in urban areas.*

*Today, at the dawn of the urban millennium, the
future of our cities is coming under increasing
scrutiny. The Tigress project, for example, has
focused on their sustainability, evaluating time-
geographical methods as a mechanism for building
the insights needed to integrate this concept into
social, economic and environmental policies. As part
of its remit, the project has developed a sophisticated
simulation model of the entire urban network in Europe based on a detailed understanding of
the role of Europe's cities and of the factors influencing their development.*

*The Eurosim model and the related research report are presented in the environment
section, which also carries results from several other EU-funded projects studying aspects of
urbanisation. These range from the management of urban water supplies and the promotion
of sustainable public transport to the changing nature of the rural-urban divide and the
complex needs of peri-urban areas.*

As usual, the articles presented in this issue of the research*eu results supplement *were
sourced from recent technology offers disseminated through the CORDIS Technology
Marketplace and the latest features articles published by the ICT Results service. In the
biology and medicine section, our selection includes details of a chemical approach which
will reduce the need for animal testing in efforts to assess the effects of pollutants. The energy
section leads with a presentation of the float wave electric power station, a technology which
converts sea wave energy into electricity. The industrial technology section showcases a new
generation of machinery designed for the manufacture of miniature engineering components.
The IT and telecommunications section opens with a report on recent developments in
quantum cryptography, a technology which may advance encryption technology sufficiently
to protect data transmissions from eavesdroppers once and for all.*

*Comments and suggestions on our supplement and on the Technology Marketplace are always
welcome. We look forward to hearing from you.*

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For more reliable computerised inspection of grinding parts

The CATIA version 5 tool can offer reliable three-dimensional data fusion and visualisation of parts in non-destructive testing (NDT) inspections.

Aiming to increase the cost-efficiency and reliability in non-destructive investigations, the INDET project introduced ICT into these processes. The project work focused on building a virtual working environment for manufacturers and NDT inspection companies. A few examples of project results include innovative multimedia maintenance manuals and web-based systems for investigation processes. Minimisation of the 'human factor' in inspection can significantly improve the reliability in measurement results.

Part of the project work centred on advanced data and information processing for remote inspection set-up and diagnosis. The CATIA v5 software tool was exploited to provide the inspector with increased visualisation capabilities for three-dimensional data. With the aid of product data management software, users can access product data from conception to support providing only a good overview of the required testing environment. Dassault Aviation worked towards optimisation of the shape and sampling of the scanning curve to accurately cover the defined inspection designed area.

More specifically, the same technique used for deriving corrected two-dimensional NDT images was applied for controlling the meshing of the part through a representative scanning curve. The retrieved information concerning each point of inspection measurement of the scanning trajectory was analysed to create a three-dimensional corrected NDT image of the inspection in ASCII format. Visual functions of CATIA v5 provide the cross-correlation matrix between a plane curve and the part surface. Most importantly, the operator is able to set the sampling steps for the main displacement and the trajectory curve.

Underpinning mobile telecommunications through advanced filters

New techniques for characterisation of the dielectric properties of thin ferroelectric films used for filtering in wireless telecommunications have been designed.

Microwave data transfer links offer high-speed, high-performance communications over long ranges with low interference rejection and high reliability. In comparison to fixed links, the use of frequency-agile wireless considerably improves the cost- and time-effectiveness of related infrastructure. Unfortunately, bandwidth availability for mobile communications (up to a few GHz) limits link capacity.

Addressing this need, the 'Tuneable filters based on dielectric resonators' (TUF) project focused on developing innovative tuneable microwave devices and technology for future mobile communication systems. This technology and its components can facilitate flexible allocation of frequency and bandwidth. The project work was centred on developing new materials for dielectric resonator filters that display extremely low dielectric loss.

The key idea was to develop high Q-factor dielectric resonator ceramics aimed to be used in channel filters. In addition, suitable methods for electronic tuning of these filters were also required. In comparison to piezoelectric and ferrimagnetic, ferroelectric films are able to tune their relative permittivity via application of static electric fields. Therefore, a thin film of ferroelectric material, when coupled with a dielectric resonator, results in effective tuning.

For the proper characterisation of the dielectric properties of thin films, two methods were developed. First, a 14 GHz split-post dielectric resonator (SPDR) was realised by the Warsaw University of Technology. This non-destructive method is suitable for the largest size on which films can be deposited. With the aid of a new generic mode-matching code for complex film permittivity patterns, arbitrary radial geometries can be easily modelled and analysed.

The second method that was developed was the stripline double resonator (SDR) that is capable of measuring the change in complex permittivity of ferroelectric films under tuning. The resonators were designed to work in the same frequency range in order to allow the use of both techniques in tandem.

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IT AND TELECOMMUNICATIONS

INDUSTRIAL TECHNOLOGIES

Chemical models predict toxicity

For each biochemical reaction, the reacting molecules must bind together like pieces of a jigsaw. Scientists have exploited this fact and developed methods to assess the toxicity of pollutants through their structure, without the use of animal testing.

Prediction of chemical toxicity on entry into the food chain is of prime importance in conservation and in the prevention of a threat to human health. The aim of the European Easyring project was to improve information regarding the environmental levels of pollutants and their biological effects on aquatic species and consequent risks for mammalian systems.

Toxicity tests have traditionally been based on *in vivo* trials, but there is pressure to limit testing on animals for ethical and economic reasons. This provided the impetus for the project team at Liverpool John Moores University to predict biological activity from the molecular structure of the pollutant. Methods of this nature are collectively known as quantitative structure-activity relationships (QSARs). Increasingly, they are regarded as a viable option for the risk assessment of molecules that might potentially be toxic to biological systems.

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The group of chemicals known as oestrogen mimics were the target for study. These oestrogenic molecules include natural and synthetic hormones, pesticides and phthalates from the plastics industry, to name but a few. They have been implicated in low sperm counts in animals and humans as well as in cancers of the reproductive system.

The team facilitated the prediction as regards toxicity by eliminating candidate molecules that would not have an oestrogenic effect. In a first step, the team applied rejection filters in the form of molecular features. The presence of a ring motif and molecular weight range were found to be the most significant criteria. The second strand of the rationalisation took into account the binding affinity of the potential toxins, and an accurate receptor binding affinity (RBA) value was determined for each molecule.

Other measures the team took into account were the variability of the living organisms potentially affected. A comparative molecular field analysis (CoMFA) supported by a structure-activity relationship (SAR) analysis was conducted. The team also identified a number of structural sites that were important for binding and performed quantitative activity-activity relationships (QAARs) to compare biological assays.

European industry groups have agreed to support alternatives to animal experimentation, and the EU is actively investing millions of euros to support this drive. These results may well represent a valuable contribution in the move to eradicate the needless involvement of animal testing that may be inhumane, costly and time-consuming.
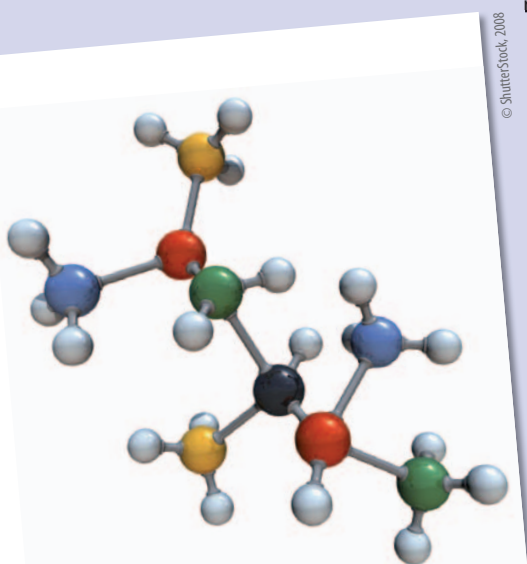
Modelling dietary toxicity data for pesticides

Data on pesticide toxicology including structure and biological activity have been collated in order to develop QSAR models. These were able to realistically predict the dietary toxicity for the bobwhite quail.

The prediction of the activity of biomolecules using databases and modelling is becoming an increasingly accepted tool, able to forecast toxicity levels for groups of chemicals such as pesticides. The use of quantitative structure-activity relationship (QSAR) models means that the preservation of our ecosystems need no longer be at variance with the economic interests of industry. QSARs may mean that more conventional time-consuming and costly biotoxicity tests will become largely obsolete.

The objectives of the EU-funded Demetra project involved the development of software for the prediction of chemical toxicity in four key organisms of our food chains. Groups involved included ecotoxicologists, representatives from industry and government bodies. To develop models involving the bobwhite quail for dietary toxicity, project partners at the Mario Negri Institute for Pharmacological Research in Italy compiled data on a set of 98 pesticides.

The two main components involved in the study were a complete description of the compounds together with reliable and comprehensive toxicity data. The Organisation for Economic Cooperation and Development (OECD) drew up principles for QSAR model validation. One criterion was that the toxicity database used should have the maximum amount of data. The group therefore selected the Environmental Protection Agency Office Pesticide Program (EPA-OPP) database for use in the QSAR model.

Additionally, several other high-quality sources of data were used for comparison as a means of ratifying the data for more accurate information. The scientists devised a method of allocating a single value for each compound from multiple data and imposed strict filtering to ensure a reliable outcome. For the compound description, the team provided three levels of information — chemical, which involves the molecular description, mathematical (the molecular descriptor) and a set of toxicity values for the compounds.

Prospective users include owners of the databases utilised. This is an indication of the level of cooperation envisaged as together they can merge the data as an 'external audit' for validity checking. Others include regulatory bodies, industry, academic researchers and the public at large as the data are freely available on the Demetra website (http://www.demetra-tox.net). It is envisaged that this work will provide the basis for the development of new QSAR approaches.

Optimising milk production

Quantitative trait loci (QTLs) are specific stretches of DNA linked to a specific phenotypic trait. Understanding how traits are inherited across generations and how QTLs are involved can be of great importance in the food and agriculture industries, among others.

The EU-funded Bovmas project focused on the genetic mapping of QTLs associated with milk production in a number of cattle populations. The aim was to put together a comprehensive database of QTL map information as well as innovative marker-assisted selection (MAS) methodologies. This type of insight could allow scientists in the future to select individual animals based on traits and thus maximise milk production from generation to generation.

Researchers from the University of Milan concentrated their efforts on the Italian Brown Swiss dairy cattle populations. Specific QTL maps for the Brown Swiss breed were not available prior to this project. Researchers tested for markers relating to milk yield and milk protein percentage; 29 and 19 markers were deemed significant respectively. Out of those, five markers were chosen for further study.

The newly available information can be integrated into breeding methodologies across Europe aimed at improving milk production and quality across different cattle breeds.

Spongy bones diagnosis more accessible

Osteoporosis is a chronic yet, in most cases, curable and preventable condition which often manifests itself at a later stage as a fracture. As a novel means of early diagnosis, researchers have measured bone porosity in the jawbone and compiled a database.

Osteoporosis is a bone disease in which the amount of bone mineral density (BMD) is decreased and the structural integrity of trabecular bone is impaired. Trabecular bone is the low-density, low-strength bone that forms the core of long bones. The high-density cortical bone also becomes more porous and thinner. This makes the bone weaker and more likely to fracture. In the EU alone, osteoporosis patients account for some half a million hospital days each year, a figure that could double during the next 50 years.

Despite these grim statistics, osteoporosis is a condition that remains largely undiagnosed in much of the population. Early diagnosis and therapy can mean that many of the serious repercussions of the condition can be avoided. Methods to identify the onset of the disease included dual-energy x-ray absorptiometry which scans the entire body, quantitative computed tomography for hip and spine, and peripheral bone density testing for heel or hand. For a variety of reasons, access to these can be limited. Aware that dental radiography is more accessible, partners in the European Osteodent project investigated this as a means of diagnosis.

At the University of Manchester, the project team compiled a database of the results. Female subjects ranged from 45 to 70 years of age and were selected from four European centres. Dental panoramic radiographs were examined by a team of oral radiologists who made measurements of a section of the width of the lower border of the jaw cortex. They also estimated the porosity of the cortex using the Klemetti index. The statistical reliability of the data was assessed on the basis of the repeatability reported by any pair of observers. Results showed that around 20 % of the subjects had osteoporosis.

An added bonus of this means of diagnosis is that it can also be used as an indication of the suitability of the bone quality for implant planning. Potential applications include use of the database as a foundation for further research into this often curable and unnecessary source of suffering. The dental industry is the other obvious beneficiary.

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Frequent acronyms

ERA	European research area
FP5/6/7	Fifth/Sixth/Seventh Framework Programme of the European Community for research, technological development and demonstration activities
ICT	information and communication technologies
IST	information society technologies
R & D	research and development
SMEs	small and medium-sized enterprises

Analysing sheep populations

Genetics combined with innovative biotechnological methods can prove beneficial in improving the quality of animal-based food products as well as animal welfare.

The EU-funded Genesheepsafety project dealt with the issues of safety and quality in the sheep food chain. The main tools of investigation were genetics and molecular biology, which were used to shed light on the genetic parameters involved in phenotypic traits.

Universidad de León in Spain, a project partner, worked with the Churra sheep breed, trying to identify the genetic loci that could confer the desired mastitis resistance trait. Further studies were aimed at the genetic loci associated with udder morphology. A number of different parameters were taken into account. These included udder depth, udder attachment, teat placement and teat size, among others.

The list of parameters is associated with aptitude for machine milking, and researchers found genetic evidence linking chromosomes OAR7, OAR26, OAR14 and OAR20 to these traits. For mastitis resistance, chromosome 20 was found to be the most likely to be involved in the somatic cell counts linked to this characteristic.

These preliminary findings should be further validated in broader populations; hence, further support is needed for this line of research. The final findings could impact on the food industry in a positive way, opening the way for innovative breeding techniques.

Disease resistance genes tracked in sheep

The livelihood of sheep farmers is often threatened by the susceptibility of their flocks to parasitic diseases. European researchers have studied the possibility of breeding for genetic resistance to sheep nasal botfly.

Meat, wool and milk are important products in the sheep industry. Particularly important in marginal hillside and mountainous regions of Europe, sheep products form the economic backbone of many rural communities. Unfortunately, sheep are prey to a wide range of pathologies and parasites.

One notable and common parasite is the larval stage of *Oestrus ovis*, a fly that lays its eggs near the nasal passages of sheep. The eggs then hatch into larvae that feed on the tissue in the nasal and sinus passages of the infected animal. The resultant disease, commonly known as botfly, causes distress in the animal and behaviour such as head shaking. Commercially, the effect is loss of milk, meat yield and poor fleece quality. Treatment is difficult, but insecticides and biological intervention through the release of sterile male flies are available remedies.

The objective of the EU-funded Genesheepsafety project, as the name suggests, was to ensure the safety and quality of food produced from sheep flocks. Research partners at the National Veterinary School of Toulouse in France studied the genome of this damaging parasite. High on their list of objectives was to find the genes or quantitative trait loci (QTLs) responsible for resistance.

One feature of the pathology of the disease is the production of mucus, an excretory-secretory product (ESP). Immunisation of sheep using the ESP produced mainly in summer months was effective in reducing the size of the larvae. Here then was evidence that partial immune regulation of the disease could be introduced.

From results of the analysis of blood samples, there was found to be a high individual variability in immune response. Furthermore, on the basis of breeding programme data, the sire or ram used was important as an immune response to the disease proved to have high heritability. Genomic studies in the form of QTL investigations were carried out. The results of the interval mapping technique were analysed by QTLMAP software developed by INRA, a project partner. QTLs were discovered on five chromosomes, two with high significance.

The results of this investigation need to be expanded to provide reliable markers for resistance to botfly. The incorporation of genomic studies into traditional breeding programmes could well herald a move away from traditional methods of disease control with chemicals in the sheep industry.

Motor cortex mirrors action

Researchers have observed brain activity that provides compelling evidence for motor cortex involvement and mirror system activation during the observation of actions.

Our ability not only to imitate, but to also understand the intentions of others through observation has long been a focus of neurological studies. Seven leading groups of scientists coordinated and cooperated in the EU-funded Mirror project to address the organisation of the mirror system. This recently discovered neurological organisation is heavily implicated in these cognitive functions.

The team based at the Foundation of Research and Technology in Crete, Greece, studied the role of the motor cortex in mimicked and observed action. To solve the debate over the involvement of this region of the brain, the 14C-deoxyglucose method was used to form a pictorial account of brain activity. This technique is based on the fact that the relative rates of glucose consumption and energy metabolism are a reflection of the level of functional activity.

Monkeys watched humans grasping a three-dimensional object or performed the action themselves. In both cases, there was significant activation of the motor cortex (MI) and the primary somatosensory cortex (SI), another region implicated in the mirror system. This provides strong evidence for the representation of an observed action in the motor cortex. The MI as well as the pre-motor region showed stimulation of the areas necessary for action. This constitutes a very convincing argument for observation and performance of action having similar effects neurologically.

The team have postulated that details of movements are stored as neurological representations in the MI and SI. Furthermore, the proprioceptive components are also in storage in the cortex. Proprioreceptors are located in the joints and muscles and provide information about limb position and movement as well as muscle length and tension.

Details of the study have been published in the journal *NeuroImage* and further disseminated at neuroscience meetings and lectures throughout Europe. Further understanding of this mechanism could facilitate the learning of motor actions involved in recreational pursuits and medicine.

Elderly care in Estonia

Findings from a study of the services and health care system provided for the elderly in Estonia have been incorporated into a book.

Demographically, Europe is experiencing constant changes, notably with regard to its elderly population. The population is rapidly ageing, and unfortunately the health and social care policies aiming to cope with this demographic change are all too often incoherent. The EU-funded CARMA project aimed to analyse the resources available and the needs of the elderly to provide the data for reorganisation of the health and social care systems.

Project partners in Estonia, a country where more than 15 % of the population were aged 65 or over in 2003, have published their detailed study in the form of a book. Entitled, in English, *Diminishing of risk of marginalisation in older people, pension systems,*

health and social care services in Estonia in 2003, it set about analysing the situation and making recommendations on the basis of the findings.

The study revealed some important factors that are responsible for a situation where elderly care is inadequate and falls short of basic needs in some cases. These include an unnecessary division of resources within the system, a lack of geriatric medicine, a nursing health care system in its infancy, long waiting lists and the high cost of drugs.

To reform the system, the study recommended that interdisciplinary geriatric assessment, better networks and a common database together with improved cooper-

ation be implemented. The recommendations do not only highlight the plight of the elderly themselves, but also suggest that more support should be given to the families of elders who often supply a crucial source of care.

Findings of all studies under the project umbrella have been pooled at conferences with the aim of exchange of information. Along with development of ideas by experts, they will no doubt contribute to the development of guidelines and protocols. Overall, they will be invaluable to policy-makers and service providers in general and enhance the well-being of Europe's elderly citizens.

Fitness for autonomous living of the elderly

In order to promote independent living for elderly individuals, the Better-ageing project studied the relationship between strength and power with performance in routine activities.

In an effort to maintain indoor and outdoor mobility, postural stability and self-care, the Better-ageing project investigated physical frailty and loss of functional independence in the elderly population. More specifically, the project work involved research on the causes of physical frailty from the whole body level down to single muscle cells. In addition, a standard physical training programme was developed and implemented for a year in order to evaluate its effects and benefits. An important aspect was the identification of the relationship between strength, power and performance in daily activities.

On the basis of an elderly population sample of healthy community-dwelling men and women above 75 years, a study was

conducted for profiling muscle function, functional ability and physical activity. The study involved partially supervised, home-based or mixed training programmes for assessing functional ability in relation to muscle power. The objective was to specify the determinants and adaptations to a long-term mixed-strength training programme of moderate intensity.

The programme was performed either twice a week in a hospital-based training facility equipped with two multi-gym machines or once a week at home with the aid of elastic bands. Examples of measurements included isometric strength of knee extensors, ankle plantar flexors and leg extensor power. In addition, abilities such as functional reach,

chair and bed rise, six-minute walking test, stair climbing, get up and go as well as one-leg standing were also evaluated.

Muscle power was proven to be a significant determinant of performance for women, while this was less important for men. Although women were generally found weaker than men, training showed significant gains in female muscle function and functional ability. Men however were shown to improve only their functional ability. Hence, adoption of a similar training programme may have a positive impact on the abilities of the elderly population, particularly the female section, in performing autonomous daily-life activities.

Studies of family carers of older people

The EuroFamCare project aimed to provide a review of the situation facing family carers of elderly people. Research was used from six European countries and results given for both the national and the European level.

EuroFamCare has provided a Europe-wide review of the situation of family carers of elderly people (aged 65 and over) in relation to the existence, availability, use and acceptability of supporting services. In total, six European countries and the World Health Organization (WHO) Europe formed a core group which, along with a further 17 European countries, produced a background report. This showed the state of family car-

ers and support services. Data from 1 000 care situations in each of the six core group countries, representing the different types of welfare state in Europe, were collected and analysed.

The results at national level have been transposed into six national survey reports. Those comparing cross-national differences and commonalities have been brought

together in the trans-European report. The national samples showed both the profile of the older people cared for and that of their carers in terms of sociodemographics, employment status, financial circumstances, caring situation, health and quality of life. A socioeconomic evaluation on the basis of the national surveys and the pan-European background information was used to calculate the economic consequences, from individual quality of life to Europe-wide politico-economic implications. Interviews were also carried out on 250 service providers from the core group, using qualitative content

Simulating surgery to reduce implant complications

A computer simulation breakthrough could mean fewer medical complications and better outcomes for patients undergoing hip, knee or spinal implant surgery.

Each year surgeons across Europe perform a staggering 900 000 hip, knee and spinal implant operations. Implant surgery is one of the most remarkable advances in medical science. Such operations restore increased mobility and a vastly improved quality of life to millions of Europeans.

Implant surgery also has one of the most remarkable success rates in medical practice, with reliable, predictable outcomes and very few complications. But it is not free of complications.

'About 10 % of operations have complications, often requiring a new implant, or a further surgery,' explains Dr Ing. Ruben Lafuente, technical manager of the Spanish IT consulting firm Adapting S.L. and coordinator of the OrthoSim project. 'It means increased pain and inconvenience, a drain on human resources, and of course it is expensive, too.'

Enter the EU-funded OrthoSim project. Set up to develop an orthopaedic surgery planning tool, OrthoSim has developed a plat-

form that can significantly reduce the risk of post-op complications, as well as provide a means for testing new implant devices, the researchers claim. And in the very near future, the platform will provide the base for a new surgical training tool.

The OrthoSim platform is a system using computer software to create anatomical and implant simulations. The simulation models are based on the work of two leading European biomechanics research centres.

'Our lumbar spinal region model is the result of over 20 years of research at the Laboratoire de biomécanique of the École nationale supérieure d'arts et métiers in Paris,' Dr Lafuente explains. 'It was enhanced and complemented by a lumbar implant model provided by the Instituto de Biomecánica de Valencia in Spain.'

These models were combined to provide a reliable simulation of the interface between the artificial implant and the living tissue, providing surgeons with vital pre-op information.

'With this service, a surgeon or implant engineer can effectively call on the expertise of the best people in any field of orthopaedic surgery, where biomechanical simulation can offer new insights for patient care,' Dr Lafuente says.

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Even better, the tool can be used to study the suitability of new implant devices and can help pinpoint any problems with the design at an early stage. 'Implant designers get the opportunity to test their new designs initially without the need for actual implantations,' Dr Lafuente notes. 'It will mean better implant designs at an early stage, cutting costs and research time, as well as improving outcomes early on.'

The models are linked together and are hosted at an online service. Integrating the various models and algorithms into a unified platform was a difficult computer science problem to solve. 'We had to work very hard to get the protocols right and we spent a lot of time developing the user interface, too,' Dr Lafuente says. 'We wanted to make the service as simple to use as possible.'

The OrthoSim project ended in March 2007, with the research team successfully combining the various elements of the project. Since then the partners have been developing the service offering further and are looking for financial support. 'Initially we had a model just for lumbar spine implants, but in the last months we have almost completed a validated model for hip implants,' Dr Lafuente says. 'We believe that once we finish perfecting a model for knee implants, we will have a very strong set of tools to offer surgeons.'

But Dr Lafuente warns that developing new products for the health market is a very difficult task in itself. 'The quality assurance and validation issues are very important in health-care-directed products, and will require more work.'

That work continues. A follow-on project, called OrthoTraining, is taking the OrthoSim toolset a step further. Over the next two years, OrthoTraining's researchers plan to develop a surgical training tool based on OrthoSim's work. 'It will enhance training for students, and it will mean that newly qualified surgeons will have better training and an enhanced skill set,' Dr Lafuente says. 'This will improve the medical services and quality of life of European citizens.'

OrthoSim was funded under the EU's eTEN programme for market validation and implementation.

analysis to structure and cluster the experience, attitudes and opinions outlined by the interviewees.

EuroFamCare has helped to promote social policies that will benefit family carers of elderly individuals. This will assist politicians and decision-makers throughout Europe to understand the critical importance of sup-

porting family carers as well as improving their situation and increasing available support measures. The in-depth knowledge derived from the participating countries covers different welfare and socioeconomic systems. Other countries can use this information to target support, identify which family carers are in the greatest need of support, determine what types of support and

services are lacking and clarify how to create more user-oriented services.

Prediction power for MAP transmission

Control of Mycobacterium avium paratuberculosis *(MAP) in cattle has proved to be a difficult task due to the elusive nature of the disease. Scientists have therefore developed models to predict the prevalence levels in herds in a range of scenarios.*

MAP is a disease that causes widespread losses in domestic ruminants. The prime means of transmission is through the ingestion of faeces. The disease may also be passed on via milk to suckling animals. Recently, it has been found in non-ruminant wildlife, and this has caused concern because of the potential infective reservoir represented by animals such as rabbits.

The disease may remain hidden or dormant within the infected animal. Young animals that have contracted the disease may not show any symptoms until adulthood, thus increasing the infective pool if not removed from the herd. The bacteria are shed with the faeces and subsequent ingestion can lead to infection.

Just how to improve control of this bacterial disease became the objective of the 'Para-TB transmission' project. Their overall aim was to identify the wild species that carry the infection and to pinpoint high-risk routes of transmission. Realistic models were developed that could predict levels of infection under a range of situations.

The project team at the University of Thessaly in Greece developed models with a range of parameters to maximise the predictive ability. The transmission from wildlife was determined at different rates from zero (shedding in faeces) to 50 %. The timing as regards culling of infected cattle was also considered to be of high importance. The periods from when symptoms were diagnosed and when the cattle became infectious to culling were varied.

Whether the calving occurred outdoors was also taken into consideration, so the situations from total calving outdoors through to calving exclusively indoors were modelled. Calving management, hygiene and location of calving were found to be much more important than the risk of infection from wildlife.

Based on comprehensive modelling parameters, these results have no doubt enhanced the predictive power of previously developed models. The highest impact from wildlife was found in large farms with solely outdoor calving. It was therefore recommended that further research regarding wild animals be carried out using these parameters.

Dissemination of knowledge about paratuberculosis

Paratuberculosis poses a serious threat to domestic animal welfare and consequently affects the viability of the European farming economy on a large scale.

The EU-funded 'Para-TB transmission' project dealt with the role of wild animal species in the transmission and epidemiology of the bacterial causative agent of the disease, *Mycobacterium avium paratuberculosis*. Part of the aim of the project was to disseminate the findings and outcomes of the scientific endeavours of the consortium.

Overall findings suggest that the role of wildlife species can constitute an important factor in the transmission of paratuberculosis to domestic animals. The Scottish cattle systems and the Greek small ruminant systems were shown to be ranking the highest in the risk-of-contamination scale. On the other hand, the risk of transmission in countries where zero grazing is common is very low indeed.

These and other findings have been communicated to farmers through Ministry and other official channels, but also directly during meetings. In addition, numerous leaflets and information material were made available in hard copy and also online through dedicated websites.

Identity cards for tracking lame cows

Recording biometric data on the individual cow and herd is now possible using a handheld PC recording system, developed as part of the Lamecow project.

Lameness costs the industry time and money. A lame cow means treatment costs, reduced fertility and an increased chance of the cow being culled due to lameness, amongst other problems. Farmers could benefit from new software developed to enable the details on a cow's health to be recorded and analysed quickly and efficiently. It allows the link to be made between the data concerning health characteristics and a registration number, date of birth, pedigree and milk yield data. This would enable the farmer to be vigilant and to spot a lame cow before the problem becomes serious.

The necessary information is recorded whilst the animal's claws are being trimmed, in the form of claw condition, lesions, disease and treatments. As information is entered, it is recorded on a pocket PC. The software program can be used on a handheld pocket PC on which the data are recorded. This portability feature allows for the collection of data at different geographical locations.

Once the information has been gathered, there are various options for analysis available to the user. The device can be linked via the Internet to download animal bio-data, which can automatically update the information for the cows already stored on the pocket PC. It is also possible to transmit the data to a central server for data analysis in conjunction with other animal bio-data

and performance records. Farmers have the opportunity to access data on each of their animals and can be given a printed version of the diagnosis made for each cow during the trimming session. The software allows for a total of 17 different claw conditions to be recorded.

In conjunction with the overall project, the software could provide a basis for the sustainable reduction in the incidence of lameness and contribute to the improvement of animal health and welfare.

Bumblebee parasite under the microscope

Intricate details of the cytology of a parasite can lead to an accurate diagnosis within a host. Scientists in the European Pollinator project have applied this to a bumblebee parasite, the fungus Nosema bombi.

Colonies of bumblebees (*Bombus* spp) are reared worldwide to fill the market for pollinators in horticulture and agriculture. Import and export of *Bombus* means that the chances of the introduction of exotic parasites into ecosystems are heightened. The consequences of the establishment of a non-indigenous species may be economic as well as ecologically damaging. In the United Kingdom, Japanese knotweed undermines flood defences, and the grey squirrel and its bark-stripping activities threaten forestry production. The EU Member States are therefore committed to the control of the introduction of non-indigenous species.

This proved to be a catalyst for Pollinator, whose prime objective was to study the bumblebee parasite *Nosema bombi* for its effective control. One of the teams based at the University of Lund in Sweden focused on the cytology of the fungal invader. The researchers studied samples of infected tissue from eight bumblebee species collected in Sweden and Denmark. Both light and electron microscopy were utilised, and an improved means of spore fixation was developed within Pollinator. From a diagnostic point of view, heavy and advanced infection states were characterised and defined. Differences between species in regards to infected tissue were also found.

All stages of the life cycle were studied. Cellular characteristics — size, plasma membrane structure, differences in appearance of nucleus, nucleoli and cytoplasmic vesicles — were recorded. The stages of spore formation were also researched. The intricate structure of the binucleate sporoblast, a stage in spore morphogenesis, was described. Finally, the ultrastructure of the mature spore, of which there can be many millions from one bee cell, was outlined in detail.

For sustainable control of this parasite, a detailed knowledge of the life cycle stages is essential. These results can form a platform on which to formulate effective control after reliable identification of the extent and stage of infection of the hive is achieved. This may well contribute to the prevention of yet another non-indigenous species invasion and the demise of the bumblebee.

Antibiotic resistance in Asian fish farms

Resistance to antibiotics within all food webs is of major concern. Researchers have investigated the incidence of resistance in the intensive rearing situations found in south-east Asian fish farms.

Widespread resistance to antibiotics is progressing at an unacceptable rate. Reasons for this are varied, but it is commonly accepted that the wholesale use of antibiotics in human medicine is an overwhelming factor. This is further compounded by their use in systems where animals are particularly prone to bacterial infection, notably in monocultural situations like agriculture and aquaculture.

Multiresistance may also be spread within the bacteria themselves. Resistance genes are frequently found on a small ring of DNA, the plasmid, in the bacterial cell. The plasmid is transferable during so-called conjugation, when genetic information is passed to bacteria that perform their version of sexual reproduction. Worryingly, a previously susceptible bacterium can then become a multiresistant microbe very easily by acquiring genes from its partner.

The EU-funded Asiaresist project, aware of the importance of aquaculture to the economy of south-east Asia, researched into antibiotic-resistant heterotrophic microbes within aquatic ecosystems. The overall aim was to use the results to identify critical control points where farmers may be able to prevent this hazard occurring. At the University of Cantho in Vietnam, a project team investigated the resistance in samples of water, sediment and cultured organisms in farms in Thailand, Malaysia and Vietnam. More illuminating still, they looked for chlor-

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amphenicol (CHL) resistance in five species of fish cultured in the Mekong river delta.

Altogether, six antibiotics were studied including CHL, ampicillin and tetracycline. Using the disk diffusion method, the researchers found varying degrees of multiresistance to three or four important antibiotics in over 50 % of isolates. The team also studied the susceptibility of CHL-resistant microbes to other antibiotics and whether the Gram status of the microbe was important. Antibiotic susceptibility depends partly on whether a bacterium is Gram-positive or Gram-negative because of differing cell wall structure. There was also found to be a significant difference in minimum inhibitory concentrations of CHL between Gram-positive and Gram-negative bacteria.

Finding antibiotic resistance in aquasystems to this extent is a serious development. However, armed with the data from these studies, strategic approaches can be devised to tackle this growing problem. The results have been disseminated as widely as possible to the interested parties including south-east Asian fish farmers, regional policy-makers and the European Commission itself. Workshops, a website and scientific publications have been the main means of distribution to enable policy to be as effective as possible.

BIOLOGY AND MEDICINE

Research driving ICT use in the health sector

Doctors are increasingly using ICT to improve the quality of care they provide to patients, a sign that EU investment into related research is yielding results.

A European Commission survey of ICT take-up by the medical profession found that 87 % of Europe's general practitioners are using a computer, and just under half are using a broadband connection. The use of electronic services in health care, known as e-health, is also making administration more efficient and cutting down on patient waiting times, according to the survey of doctors.

'Europe is starting to reap the benefits of broadband connections in the e-health sector,' said Viviane Reding, EU Commissioner for Information Society and Media. 'This diagnosis also shows that it is now time to use these electronic services much more widely as they have the potential to bring extraordinary benefits to all patients, all over Europe.'

The survey shows that about 70 % of European doctors use the Internet and 66 % use computers for consultations. However, technology for monitoring patients remotely, called telemonitoring, is only used by doctors in Iceland, the Netherlands and Sweden, and even in those countries it is only provided sparingly.

Administrative patient data are electronically stored in 80 % of general practices, while 92 % of these also electronically store medical data on diagnoses and medication. About 35 % electronically store radiological images. About 40 % of European doctors often transfer data electronically with laboratories, but only 10 % to other health centres. Moreover, using ICT to share data among general practitioners in other Member States is rare, with only 1 % saying they exchange data across borders.

But European researchers are providing the techniques to help more doctors incorporate ICT as part of their provision of patient health care. They are developing technologies that could lead to significant advances for both doctors and the patients they treat, as can be demonstrated by the EU-funded projects covered so far by *ICT Results*. Here is a selection of some of those results.

For example, the Akogrimo project team is developing the potential of telemonitoring by developing a grid to bring diagnostic tools out of hospitals and into the field. The results of their work will potentially give paramedics and other mobile response units access to powerful tools previously beyond their grasp. The Akogrimo project was designed to link not only organisations but also individuals, often using mobile devices. The grid can accommodate virtual organisations that are set up in advance for day-to-day tasks and also those that are created at very short notice, such as in a crisis situation.

Along similar lines, the Palcom project focused on reducing complications associated with technology. The researchers' aim was to use so-called 'palpable' computing — pervasive computer technology that is also tangible and comprehensible to its users. Such technology allows for a quick fix of communications breakdowns. The EU researchers behind the project are now applying the technology to help women through pregnancies and to improve the treatment of hip-replacement patients. Another palpable computing system they are developing is aimed at enhancing post-surgery monitoring and will allow hip patients to leave the hospital 24 hours after surgery, rather than the current three or four days.

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Keeping an eye on patients after they walk out of the surgery door may seem more like science fiction, but European doctors and technicians are perfecting a medical support system that can track patients' real-time vital signs, link those to patient medical history, and, crucially, provide the latest clinical guidelines for patient care.

Better yet, the system can alert doctors in case a patient suffers a setback. The system is called Saphire, after the project of the same name. Saphire offers a range of services that combine scattered information stored across different systems into a new, more powerful application.

Researchers at another EU-funded project, Biotex, also developed a new method of monitoring patients in real time. The researchers tapped into the ongoing development of smart fabrics to create items of clothing that can measure a wearer's body temperature, trace their heart activity, analyse body fluids, and provide another way to continually assess someone's health. 'It's new and health care providers are not used to it,' says Jean Luprano, a researcher at the Swiss Centre for Electronics and Microtechnology who is also the project's coordinator. 'We are not used to the information that continuous, remote monitoring can provide — so different to the one-off laboratory tests that are usually taken. Biotex technology makes this remote monitoring possible, but more research into the links between these indicators and disease conditions and states will make it realistic.' He expects continuous monitoring, made possible with smart textiles, to make a major improvement to the way doctors approach the treatment of metabolic disorders and leisure.

Following a simpler path, researchers at the Attentianet project developed a way of using a telephone line to communicate with an assistance centre set up for providing health care at a distance. While such technology is already in use for many house-bound or elderly people, the project resulted in a system that uses broadband communications and video telephony. A mobile system is also used to allow tracking of individuals. Such a device can easily be slipped into a pocket while everyday life continues, and the person can be safe in the knowledge that a video tele-assistance centre is permanently on call. Making the system user-friendly was obviously a key concern for the researchers, and they used a special and very simple mobile phone with just two buttons.

Bringing together scattered information from around the European bloc as citizens become more mobile was addressed by the

RIDE project. The research team sought to chart a road map for e-health interoperability that would eventually hook up the EU's health information systems in a seamless web. The ideal is that in the future, Europeans will be able to go to any EU Member State and not sense any difference in the quality of health care they receive. Doctors and health bodies will be able to access information on foreign patients just as easily as they do for local ones, and patient records will be accessible at any time from anywhere — not only for professionals with the necessary access rights, but also for the patients themselves.

General practitioners and administrators are not the only ones who could benefit from ICT. Results from the OrthoSim project look set to benefit orthopaedic surgeons by producing a platform to reduce the risk of post-operative complications. The platform uses computer software to create anatomical and implant simulations, which can reliably model the interface between an artificial implant and the living tissue, giving surgeons vital information before the operation has even begun. 'With this service, a surgeon or implant engineer can effectively call on the expertise of the best people in any field of orthopaedic surgery, where biomechanical simulation can offer new insights for patient care,' says Dr Ing. Ruben Lafuente, technical manager of the Spanish IT consulting firm Adapting S.L. and project coordinator.

Improving the odds for patients is clearly a priority of ICT medical research. The Clinicip project looked at boosting the odds for those with the odds stacked against them — patients in intensive care units (ICUs). For such patients, treating high glu-cose levels can be a real challenge, and so the project set about developing a new automated delivery system. Nurses still have to draw blood, which is analysed in the traditional way, but then the new system takes charge, calculating how much insulin is needed and automatically administering it.

European researchers have also turned their attention to improving the lives of the 2.5 million or so people worldwide who are wheelchair bound because of spinal injuries. About half of these people are quadriplegic, paralysed from the neck down. The MAIA project aimed to help these people regain some independence by producing a new type of non-intrusive brain-computer interface (BCI). Using electrical signals emitted by the brain and picked up by electrodes attached to the user's scalp, the system allows people to operate devices and perform tasks that previously they could only dream of. So far, the team has carried out a series of successful trials in which users have been able to manoeuvre a wheelchair around obstacles and people using brainpower alone.

Except for OrthoSim, all of the research projects mentioned above received funding from FP6. OrthoSim was funded under the EU's eTEN programme for market validation and implementation.

Between the early 1990s and 2004, EU research funding has supported e-health to the tune of over EUR 500 million, with total investment due to co-financing adding up to about twice that amount. All this has helped to create a new e-health industry with an estimated turnover of EUR 11 billion, according to the Commission. By 2010, estimates suggest that up to 5 % of health budgets will be invested in e-health systems and services.

Current initiatives stem from the action plan adopted by the Commission in 2004 to develop the use of ICT in the health sector. As a result, all Member States put in place strategies to accelerate e-health deployment (http://www.ehealth-era.org). E-health is also targeted as part of the lead market initiative for innovation launched by the Commission in 2008.

The current European Commission survey, published on 25 April 2008, takes the pulse of e-health in Europe. The survey collected responses to questions from about 7 000 general practitioners. It found that a majority of them agree that ICT improves the quality of the health care services that they provide. Doctors not using ICT cite a lack of training and technical support as major barriers. To spread e-health, they ask for more ICT in medical education, more training and better electronic networking among health care practitioners wanting to share clinical information.

EU-funded research is addressing those demands. In addition to providing technologies already in use by the medical profession, ongoing EU-funded research is currently preparing technologies from which doctors will be able to benefit in five years or so.

For news on other EU-funded developments in the e-health sector and on other ICT projects, please visit the ICT Results website.

Promoted through the ICT Results service.

http://cordis.europa.eu/ictresults/index.cfm/section/news/tpl/article/BrowsingType/Features/ID/89710

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BIOLOGY AND MEDICINE

Intelligent plant breeding

Improving selection strategies to accelerate resistance breeding may well lead to improved quality wheat cultivars and better conditions for European farmers and consumers.

The presence of the *Fusarium* head blight (FHB) fungus in wheat and oats infects the plant and produces mycotoxins, which can easily infiltrate the food chain and impact upon food safety. In order to investigate what can be done about this, the Fucomyr

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project was set up with the goal of developing novel tools for *Fusarium*-resistant and toxin-free wheat. Taking part in the project was a consortium comprising research institutes and SMEs in the wheat breeding sector. Experiments were conducted during three seasons and in five locations across Europe in order to characterise FHB resistance in the plants.

The experiment used *Fusarium* inoculum which was applied by spraying directly onto the heads of the plant or by spreading *Fusarium* debris onto the soil surface. Mainly winter and some spring wheat genotypes from diverse sources were tested. Resistance was compared and both resist-

ance against penetration of the ear (type I) and resistance against fungal growth subsequent to infection (type II) were monitored. Highly significant differences between FHB resistance lines were detected. The most promising resistance lines were used by private breeders in their crossing programmes. Furthermore, the resistance data of the individual lines are available and can be compared by any third party.

The findings of this project will directly apply to the improvement of artificial inoculation techniques used so far. In the long run, this will mean the production of high-quality wheat cultivars. The attainment of this would lead to European farmers becoming more competitive both in domestic and world cereal production markets. Healthier plants with less risk of mycotoxin infection will also contribute to a healthier diet for consumers.

Drinking to the success of mountain wine producers

Fine wines are available from the mountainous areas of Europe. In order to preserve their existence, scientists have studied the intricate details of the wine-making process and the vines themselves.

Oenology, from the Greek *oinos* meaning wine, is the study of the production of this seductive drink. In many European mountainous areas, oenology is a deeply traditional industry, and old varieties of grape indigenous to that area often yield a very distinctive wine. It was the aim of the 'Eagle wines' project to give support to the mountain viticulture industry. This involved two main objectives. The first was the conservation of unique indigenous wine grape varieties that would be threatened with extinction without wine production. The second aim was to provide strict and systematic methods in order to obtain wine of continuing high quality and commercial value.

The project team from La Crotta di Vegneron, a wine cooperative in the Aosta Valley in Italy, undertook the second task. The attention to detail both in the vineyard and the wine-making process itself is crucial for production of wines with consistently high standards. The protocols developed covered all aspects of wine production. These included steps ranging from grape crushing and removal of stems right through to various processes after fermentation has finished. For example, tartrate stabilisa-

tion is performed to avoid the production of crystals on chilling, an off-putting characteristic for the wine drinker. Also, testing for phenols is the most important feature because they affect quality, flavour and stability. Finally, a subjective consumer test was performed on the bottled product.

The wine-making industry is not solely about the production of the drink. Before the process even begins, growers are concerned about identification and selection of appropriate varieties of grape. This involves knowledge of their morphological characteristics including descriptions of buds and bunches, essential information for their inclusion in the national grape varieties catalogue. Also helping the producer in standardisation is the study of grape ripening. Ripening of the fruit is a complex

chemical pathway. Harvesting of the grapes at the correct time for optimum sugar and acid content is highly important.

The successful perpetuation of wine-making in mountainous areas of Europe will require support for SMEs. This is necessary to allow for shortfalls in sometimes family-run businesses where equipment or finance are limited. The results of this project represent tangible support for small wine-making businesses, making sure that a fine, unique bottle of wine will still be on the table at dinner.

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Determining plant suitability to light or shade

A method for ascertaining whether a plant is best suited for shade or light conditions has been developed.

The Plants project has focused on the development of interactive, scalable mixed communities for conveying the link between artefacts and plants. It is foreseeable that the spaces in which we live will become furnished with countless 'artefacts'. These artefacts will be capable of sensing and actuating their environment to enable localised computation, communication and collaboration amongst one another.

Until now, this aim has fallen short in that the link between the ambient electronics environment and nature has been missing. This is because research has been conducted in enclosed laboratories, offices and artificial living spaces without any meaningful interfaces with nature. Therefore, synergies between living organisms and ambient systems which are able to observe their unpredictable behaviour needed to be created. The Plants project has done just that, focusing specifically on plant life.

In regards to plants purchased from garden centres and nurseries, the buyer usually relies on the producer for information about conditions suitable to the plant. In most cases, the plant is not grown in the most suitable conditions because of space and production pressure limitations. Therefore, commercial shade and light plants can show indistinguishable electron transport rate (ETR) readings.

Given this, a method was developed to determine plant suitability to light or shade using ETR threshold levels upon purchase. An ETR curve is obtained through the use of chlorophyll fluorescence, which is then analysed to provide the inflection point of the curve. This is useful for interior and exterior landscapers in the determination of the best plant positioning.

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Super-plants against nematodes

Parasitic nematode worms can have a deleterious effect on the quality of agricultural produce, with devastating impact on rural economies.

The EU-funded Nonema project carried on the legacy of previous projects aimed at protecting plants from nematode infections. Project partners worked with potato and tomato plants to engineer new plant breeds which can carry the molecular mechanisms to resist infection from nematodes.

Part of the project objectives centred on fully understanding the mechanism surrounding the infection path of the nematode *Meloidogyne incognita*. For this reason, a number of studies were carried out examining the genetic events that are carried out within the parasitic organism during the early stages of infections.

The expressed sequence tags (ESTs) studies were used to provide information on which genes were expressed within the nematode worm during the onset of parasitism. A number of ESTs were identified for a multitude of genes associated with parasitism. These tags could provide research groups with the building blocks needed to interfere with the plant-parasite interaction, thus rendering the plant resistant. Engineering this newly gained information into new plant breeds is dependent upon continuing research support.

Getting rid of the worm in your apple

A novel pest control management technique was conceived in the framework of the 'New insect control' project that uses pheromones to deal with the codling moth.

The codling moth is the bane of the apple farmer. Its larvae burrow into the core of the apple, causing irreversible damage. Unfortunately, ridding apple orchards of codling moths requires the application of pesticides that can negatively impact other components of the ecosystem.

Working with funding from the 'Life quality' programme, a research consortium investigated the possibility of natural biological controls. The project coordinator, International Pheromone Systems Ltd (IPS), created a castellation trap with pheromones, special chemicals used to communicate between members of the same species.

Specifically, pheromones are used to draw male codling moths into the trap, where they are infected and then returned to the wild. The aim is to create disruption in the local codling moth population, thereby limiting reproduction and subsequently the risk of infestation.

The new traps were initially tested in a wind tunnel and then used in a number of field experiments in Spain and the United Kingdom. Fortunately, no side effects on other species were detected. However, the traps were not as effective as had been hoped in reducing the number of codling moths and subsequently apple losses.

IPS and its partners are investigating alternatives with respect to the pathogen used to infect the male codling moths. Moreover, the trap structure will be redesigned to enable trapping in addition to the original trap-and-release version. IPS has applied for patent protection for the new trap.

BIOLOGY AND MEDICINE

Computing optimal food freezing and thawing conditions

In response to rising food safety standards and the growing complexity of the food supply chain, elaborate software tools capable of assessing the safety and quality of frozen food products have been developed.

Risk assessments for food safety are vital and necessary for asserting food quality and therefore consumer acceptance. Several of these safety and quality aspects arise when food is processed at low temperatures. Optimum freezing and thawing of foods

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like pork, salmon or potato presupposes accurate knowledge of the thermo-physical properties of water. The 'Safe ice' project has accumulated systematic data regarding these properties and, with the aid of elaborate software tools, the optimal food freezing and thawing conditions can be determined.

Pressure and temperature are the two critical parameters that control the phase change of any liquid into a solid or vice versa. Water turns into ice at 0 °C only when the pressure is 1 atmosphere, that is, at the usual atmospheric pressure. During this phase change, a number of physical parameters are important for food processing. Specific volume, specific heat capacity, thermal expansion coefficient and adiabatic compressibility coefficient for both water and ice must be known at any

temperature and pressure combination. The 'Safe ice' project has evaluated these parameters and subsequently developed a user-friendly software algorithm that permits calculation of the above parameters for any given values of pressure and temperature.

Moreover, with the aid of simple analytical models, an estimation of these thermo-physical parameters has been performed for a number of model gels. Specifically enthalpy, apparent specific heat and thermal conductivity of tylose, a water-soluble, non-ionic cellulose ether, have been evaluated.

Data produced from the developed software combined with data obtained from calorimetry studies have been compiled in a CD-ROM. Any thermo-physical property for any food material can now be calculated on the basis of temperature and pressure alone.
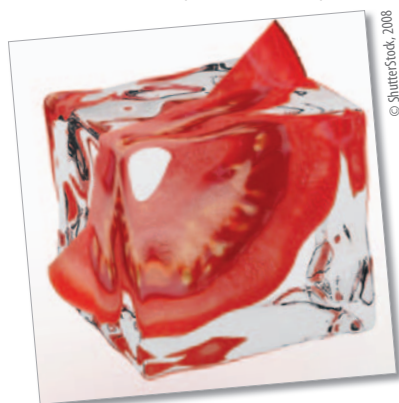
Relief for neurogenic incontinence

Neurogenic incontinence is a very common problem, particularly among those with spinal cord injuries. A consortium of scientists has researched into the development of a novel system for conditional neuromodular stimulation to alleviate this condition.

Neural injury, diabetes and multiple sclerosis, among other conditions, can cause neurogenic incontinence due to changes in nerve function between the brain and the bladder. This is a distressing condition where the quality of life of the patient is reduced considerably. The REBEC project has investigated neuromodulation as a therapy for this type of incontinence. Neuromodulation refers to the procedure whereby electrical stimulation is used to alter nervous system function.

One of the project teams at the Fraunhofer Institut Biomedizinische Technik in Germany researched two aspects of neuromodulation. The team investigated the neurological function from the point of view of signal control. Then, for the stimulation

itself, the team developed electrodes for the production of the neural signal. These could then be incorporated into an implantable device.

In order to implement an impulse stimulation system, an eight-channel stimulator to apply arbitrary, shaped stimulation pulses was developed. The system is computer controlled and the program can be run on any PC via a graphical user interface. This new system is innovative in the sense that there can be better physiological tolerance of the nerve system due to the arbitrary nature of the impulses.

The researchers also developed biocompatible hybrid cuff electrodes. These were specifically designed to stimulate and

record impulses from the sacral nerves. The cuffs were designed in a tripolar electrode arrangement in different diameters. Moreover, the electrodes were subject to rigorous standards tests on both the raw materials and the ethylene oxide (ETO) sterilised finished product. Therefore, no bio-incompatibilities are to be expected during clinical use.

Many patients with neural transmission problems who require the intervention of insertable electrodes could stand to benefit from this research. Incontinence, pain relief and deep brain stimulation are all possible applications. The method for conditional neuromodulation has been patented and can be applied in future research for incorporation into implantable mechanical devices.

What is a technology offer?

All research results uploaded on the Technology Marketplace are assessed by CORDIS to reveal their exploitation potential. The top ones are selected and rewritten as technology offers in a journalistic style. Online, each offer is linked to the related result.

Tempted by a technology presented in this issue?

All of the projects presented in the supplement are seeking cooperation partners in specific areas, and interest in their work is welcomed. Please contact their coordinators directly if you would like to know more about them.

Harnessing sea waves

A new offshore device, namely the float wave electric power station (FWEPS), has been designed to convert wave energy into electricity.

The Marineco project focused on the economic and societal development of remote Arctic regions without putting the wilderness area at risk. The primary objective was to exploit regional energy resources for developing environmentally friendly power-industrial technologies. In the Arctic as well as in other remote regions, sea waves constitute the most available and promising energy carrier among other renewable sources.

The key concept was to study, build and demonstrate a viable, environmentally safe power-industrial system based on sea wave energy. Consequently, project partners developed a pilot module of the ecologically compatible, offshore FWEPS as a device for sea wave energy conversion. The FWEPS can be readily deployed in seas and oceans even under the most unpredictable conditions during seasonal or regional wave activity.

The developed module is a sealed capsule-float that includes a mechanical oscillatory drive, an electric generator and an auxiliary energy storage unit. The oscillatory drive is required to match the time variable properties of the wave space in order to exploit sea waves more effectively. Moreover, the axially symmetric streamlined shape of the device allows better navigation with a vertical deposition of the float on the sea surface.

The innovative design facilitates sustainable operation at variable lengths, velocities and intensities of waves as well as directions of their propagation. Apart from its capability to adapt to the continuously changing external conditions, the FWEPS is also

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extremely reliable. Its proper sealing offers full protection against the corrosive attack of sea water and its vapour, and thus a long life-cycle for the device. For more information, please visit the project site: http://www.marineco.org

Sea water for the fuel of the future

Sea water is probably the most widespread, clean and economical source of sustainable energy resources and other products. Marineco scientists have researched into the verification of a technique for its electrolysis to yield the fuel of the future: hydrogen.

Sea water is a natural electrolyte. Unlike most other water sources on our planet, it has a high level of ionic salts that are necessary for the electrolysis process to be effective. The Marineco project aimed to make electrolysis of this valuable natural resource the basis for the development of a power-industrial system for the Arctic region. The amazing feature of this ambitious plan was that all the technology, from wave power to hydrogen and oxygen production, was based on the vast volume of naturally occurring sea water surrounding the continent.

Russian-based project partners at the Applied Technologies Company Ltd researched into the design of the electrolytic equipment on a laboratory scale to optimise the yield of the products. The products from the electrolysis of sea water are mainly hydrogen, oxygen and chlorine. The respective yield at the anode of gases oxygen and chlorine is dependent on factors such as the chloride ion concentration, temperature and the anode current density. All these can lead to the overproduction of a product that may not be required at that time. Although chlorine has many industrial uses such as the production of hypochlorite, a disinfectant, it is essentially a highly toxic gas. The overall aim was to limit its production in favour of oxygen.

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The experiments were carried out in a single-cell model with electrode chambers separated by a membrane that allowed the exchange of ions present. The current-voltage characteristics and the content of anolyte and catolyte were defined along with the resultant quality and quantity of gases produced. Overall, this method of sea water electrolysis seemed very promising, yielding products with valuable, sustainable uses. Hydrogen of course is an energy source and is the potential fuel for fuel-cell vehicles. It is also used to make fertilisers, glass, soaps and even margarine and peanut butter. Other commercially viable products include magnesium hydroxide, which among other uses is a flame retardant and a cure for indigestion.

At a time in our planet's history when greenhouse gas production is running amok and our fossil fuel resources are running out, technology of this nature could be a valuable part of the rescue remedy. Parties interested in further information on this environmentally friendly research can access the website at: http://www.marineco.org
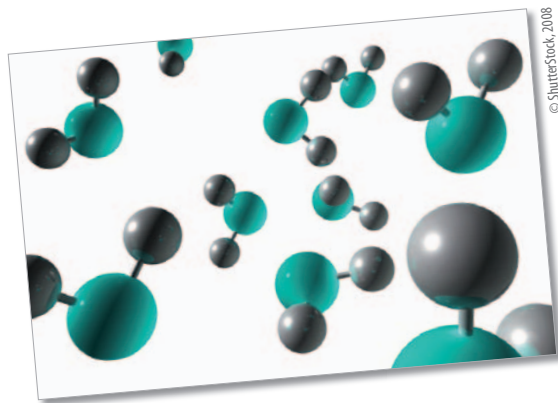
Aiming for high-silicon steel

The Diffansteel project developed a cold rolling process which is part of an energy saving route for developing high-silicon electrical steel.

The use of high-silicon electrical steel in transformers and motors can lead to significant reductions in energy losses. Due to the material's brittle structure, an economically viable way for its production has not yet been found. Motivated by this observation, the Diffansteel project focused on working on the conversion of a low-silicon steel to a low-loss high-silicon steel. The initial aim was to employ silicon-rich coating techniques and diffusion annealing in order to achieve uniformity and high silicon concentration.

Part of the project work involved a cold rolling process as an intermediate step between the hot dipping with aluminium-silicon and diffusion annealing. This was considered necessary for increasing the silicon content in the semi-final thickness strip. Another advantage of this additional step is the optimisation of the surface finish after dipping. The intermediate cold rolling process leads to a flatter, more uniform strip with optimised magnetic properties.

The basic concept behind this project work was to produce new, inexpensive, low-energy-loss magnetic material for energy-saving electrical machines. Although most of the technical challenges were successfully addressed, the properties of the resulting steel were not in accordance with the expected ones despite several technological achievements. A few examples of these achievements include the definition of the hot dipping, the diffusion annealing and pickling parameters and the patented intermediate cold rolling step. All the successful results are expected to assist future EU steel processing developments and stimulate research into understanding the mismatch between predicted and measured properties.

New approach to renewable energy

As part of a project modelling sustainable economic structures, a new paper on the subject of renewable energy technologies puts forward recommendations for advancement in the field.

Carbon capture and storage (CCS) technology has recently entered the forum in the discussion on the reduction of carbon dioxide emissions. The challenge of reducing the level of carbon dioxide emissions has been at the forefront of the debate on the environment for many years now. A consensus has finally been reached by policymakers and scientists alike that at the very least, a partial decarbonisation of energy use is necessary. This is of course an ambitious challenge to realise in practice. Therefore the exploration of options that go beyond the transition from carbon-intensive fossil fuels (coal and oil) to carbon-poor ones (gas) is duly receiving more attention.

The research paper, produced at the Energy Research Centre in the Netherlands, is a continuation of the Transust project. It is based on answers given by members on how the models developed in the project simulate CCS and renewable energy technologies. The Transust project brought 11 models to fruition, and the paper states that out of these, only a few actually include CCS and renewable energy technologies. Those that do investigate the long-term significance in energy and climate change scenarios.

Recommendations on future model development are drawn from the paper. Firstly, it recommends that for those models that do not include CCS and renewable energy technologies, headway should be made in terms of the refinement and improvement of their simulation of these technologies.

Emphasis is put on the fact that today insufficient attention is being paid to possible external environmental effects of carbon storage. The paper stressed that, in the future, attempts need to be made to include the impact of carbon storage in the present generation of integrated assessment models.

Smart charging for hybrid electric vehicles

A special battery management system (BMS) was designed to optimise the charging of a new bipolar lead acid battery for hybrid electric vehicles (HEVs).
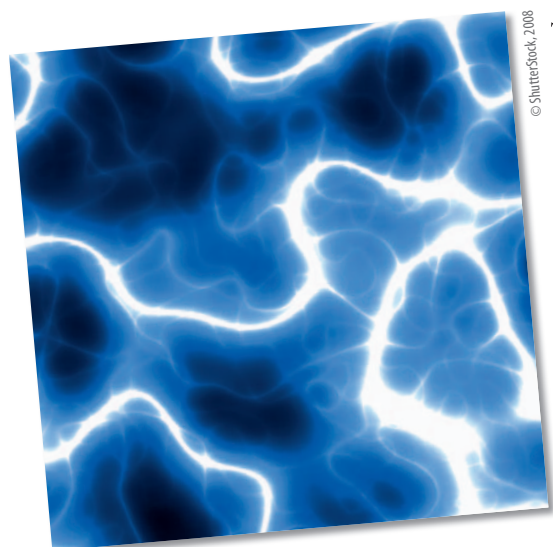
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The Bilaps project realised that new battery technologies are required to support the rapidly expanding market for HEVs. They looked beyond the current nickel and lithium battery types in favour of a lead acid battery in order to minimise costs.

The challenge was to improve the power output of a lead battery prototype. This was accomplished by adopting a bipolar design concept in conjunction with an advanced BMS. A2E Technologies/Enertronic, a Bilaps partner, employed an approach whereby the bipolar cells, which are connected in series, are controlled individually. This is achieved with the help of slave chargers that are attached to the cells with faston clips. A single master unit monitors the charging profile of each cell.

The BMS was subjected to several tests during the four-year Bilaps work programme. Following a number of revisions, A2E was able to further enhance the capacity of the BMS to charge the new bipolar lead acid battery. The cost-competitive Bilaps energy storage system is appropriate not only for HEVs, but also for other battery-powered means of transport.

Monitoring the robustness of distributed generation

A study by the French firm IDEA is paving the way for the successful introduction of distributed generation in Europe's electrical networks.

Europe has mounted a campaign to increase the amount of power it generates from renewable energy sources (RES). As a result, the electricity network will become increasingly distributed, reaping significant technical, economic and environmental benefits.

The European Commission is funding R & D to help speed the adoption of cleaner energy sources. The CRISP project, for example, sought to enhance distributed generation with the latest information and communication technologies.

IDEA, a company active in electrical network research, examined the issue of robustness of distributed generation during CRISP. The team started with a complete description of the network, focusing on the aspect of transmission. Reliability was expressed as a function of the degree of distributed generation penetration. Measures to avoid blackouts were also taken into account.

During CRISP, IDEA invented an index that provides an accurate assessment of system stability in real time. The index is calculated at the local grid level, but can also be integrated over larger areas. This flexibility allows the management of both local and global constraints.

IDEA also examined how to deal with the repercussions of intentional islanding, a phenomenon associated with increased RES infiltration. Finally, they devised the necessary controls and communication mechanisms to ensure secure operating conditions.

For increased use of wood biomass for energy

An innovative web geographical information system (GIS) application aims to optimise the utilisation of wood as an energy source in thermal biomass plants and to create new market opportunities.

There is a significant need for new knowledge about the generation and use of bioenergy in Europe, as well as for cooperation between European countries sharing common interests. Insufficient communication would affect the rational cooperation between different sectors, different parts of the value chain from the forest to the power plant and different decision-making levels.

The Echaine project's ultimate aim was to provide efficient tools for the identification and evaluation of economical and environmentally friendly supply chains of energy wood. More specifically, a multidisciplinary approach was adopted by an international scientific network comprising members from nine European countries to build efficient communication links.

Data for analyses were collected from field experiments, research reports and interviews with farmers, forest owners as well as contractor companies and citizens. Subsequent analyses of the current technological state of energy wood production and utilisation for heat and power generation could help identify the range of application in individual countries.

To combine spatial data generated within the various parts of the project, an interactive GIS application was developed by researchers at the Atos Origin laboratories. Based on web technology, it allows sharing data from different sources of information and covering technological along with the most relevant socioeconomic aspects of the utilisation of energy wood.

The final version of the interactive GIS has been integrated in the Echaine project site: http://www.echaine.org

Superconductive cables for power delivery

Enormous advantages come from using superconductive cables for power delivery. Electricity bills, for instance, could be greatly reduced. Some of the many obstacles encountered in their application have been solved.

Scientists estimate that market applications of high-temperature superconductive (HTS) materials will emerge 10 years from now. It is rather unlikely that superconductive cables will ever be used for power delivery in our homes but, for industrial and scientific purposes, their fabrication is of great importance. Their expected market applications will be many and diverse. The Big-powa project has indicated that Europe will have a large piece of this emerging market and will successfully withstand fierce competition from Japan and the United States.

One serious problem HTS wires are faced with is the great electrical losses when an alternating current (AC) field is applied. This is because the AC electric field generates a magnetic field which, as it moves through the cable, gives rise to a so-called hysteric loss. These losses occur even when the superconductor is below the critical current and are linearly proportional to the current passing through. Until now, cables using straight tapes of the ceramic bismuth strontium calcium copper oxide (BSCCO), the 'bisco' filament, enclosed in a silver matrix have been used. To reduce AC losses, project partners were able to fabricate a cable using twisted tapes of BSCCO embedded in a pure silver matrix. The sample cable has a round form, 2 layers helically wrapped with 15 tapes in each and copper terminations.

This flexible, tape-twisted cable has undergone extensive experimental testing that showed reduced power losses compared to the straight tape used for small currents. The method used was the electric option where power is simply calculated as the product of current, voltage and the phase between the two. Due to the filaments' magnetic coupling, high-current results were not so auspicious.

Project partners utilising magnetic decoupling in the high-current regime will no doubt bring the more powerful, smaller and lighter HTS cables closer to commercial use.

ENERGY

2050: A city odyssey

The Tigress project created a simulation model, Eurosim, of the entire urban network of Europe. It charted different activities in order to analyse whether the trajectory of the urban system will develop in a positive or negative way.

Cities in developed countries no longer follow the same patterns of growth. Trends we are used to, such as migration from rural areas to cities, are beginning to change. This raises questions as to whether the spatial and activity patterns we have seen so far in metropolises will continue along the same lines. If not, what will change and how will it affect our society? These were some of the questions addressed by the Tigress project.

The project was coordinated at the Université de Paris 1 Panthéon-Sorbonne in conjunction with Research Institute for Knowledge Systems (RIKS) in the Netherlands and the University of Newcastle in the United Kingdom. From a theoretical point of view, the principal innovative features of Eurosim are that it provides a combin-

ation of networking principles with spatial proximity principles. Networking has been* modelled in applications in sociology and in economics, but without integrating the spatial dimension. Furthermore, Eurosim considers multiple levels when analysing the outputs; it looks at the macro-structure of a system as well as in the dynamics of individual cities.

One of the applications of the model is that it could help policy-makers think about urban futures in a way which takes account of knowledge about the dynamics of activities in urban systems. The model could be applied to the study of local or supra-national change, cross-border migration or the effects of European enlargement.

It would be interesting in the future, says the report published on the project, to use the model in order to test the role of political or economic macro-actors on the evolution of cities. One of the most surprising findings in the report was that although London and Paris, the two largest European cities today, remain at the top of the European urban hierarchy in 2050, London clearly dominates Paris. The advantage of London is that of benefits of a larger regional and national supporting base. The full report is available at: http://www.tigress.ac/reports/final/eurosim.pdf

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Closing the cycling gap

Measures have been taken in the German city of Bremen in order to create additional alternative solutions for reducing car use and increasing cycling.

The Vivaldi project has undertaken some significant elements of the targeted plan for cycling. Several measures were implemented. For example, a contraflow lane for cyclists was established to improve their physical safety, a set of traffic lights was installed at a crossing and road space was reallocated.

Further changes included a reduction in the width of the road lane and new cycle paths and a roundabout which can improve the

physical safety and convenience of cycling. Construction work which lasted nearly two years brought a renewed road lane as well as new rails and stops for the tram. Additionally, vegetation and trees were planted and walking paths were implemented. These changes have made it safer for pedestrians, for cyclists as well as for users of public transport.

Respondents claimed that the new cycle paths would lead to more frequent cycling.

Furthermore, most residents in the area claimed that the appearance of the street has been improved, which in turn has helped to increase the overall quality of life.

Better transport alternatives

Alternatives to car use have been created in order to improve and promote new public transport facilities in urban areas in France.

The Vivaldi project provides innovation in the areas of clean vehicles, stimulation of collective transport and new forms of vehicle use, among others. Under these auspices, a new railway link between the cities of Vertou, St Sébastien and Nantes, new railway stations, park-and-ride facilities and connections with the bicycle network were created. Furthermore, a large inner-city highway known as the RN801 motorway located in an urban area has been reconstructed.

Many benefits have been seen and are still expected to arise. A restriction of the number of car lanes, speed limitation and the creation of new inter-district links have resulted. Additionally, a new concept for the fourth major public transport route of the urban network known as the BusWay has been created. The creation of RN801 has had the positive outcome of reducing car traffic by half. Park-and-ride contains 360 parking spaces as well as spaces for cycles

at the two new stations located between Nantes and Vertou. Railway station passenger use in Vertou and in St Sébastien tripled in one year and continues to increase.

Those who will benefit from the improved public transport facilities include visitors, commuters, children and teenagers from south suburban areas and south sector residents.

Addressing the rural-urban divide

Rural areas are experiencing new relationships with their urban counterparts, but not without cost. A study examining rural areas from Spain to Finland published its findings in a report which stresses the importance of sustainable development.

Rural areas in Europe need to be protected and encouraged to flourish both economically and socially. The aim of the research project 'Building new relationships in rural areas under urban pressure' ('Building urban rela') is to readdress the balance offset by the difference in support given to those who make their living working outside of the city. Rural areas need support to provide rural goods and services related to the landscape and to get compensation payments by new relationships with urban society. Rural goods and services include first and second houses as well as tourism and gastronomy with agri-food marketing. The project analyses the relationships between rural and urban actors in order to assess each actor's role in enhancing the diversity of rural landscapes.

The research institute involved in the project has now published a report which summarises the results. This provides a summary of the key factors in the supply and demand of rural goods and services. It explains that demand originates from urban people for whom it has now become important to live and recreate in a rural setting, but who work in towns inside or outside the region. The demands placed on the rural landscape for housing and facilities could potentially conflict. Planning the use of rural space for public activities such as recreation parks needs to make use of zoning, compensation payments and agreements, procedures that have been implemented in cities for decades now.

A main conclusion that came out of the report is that 'commodification without destruction' is crucial to the demand and supply of rural goods and services in rural areas. Looking at the evidence, the report describes Finnish, Hungarian and Spanish rural areas to have experienced relatively high levels of commodification, whereas the opposite was found to be true of the rural areas studied in France and the Netherlands.

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Grid-enabled air pollution modelling

Funding from the IST programme helped bring the power of grid computing to environmental applications, specifically attempts to forecast air pollution.

Air pollution models are useful tools that can predict pollution episodes in advance, allowing local authorities to implement the measures necessary to protect public health. Pollutant emission sources and weather conditions must be properly addressed in order to produce accurate forecasts. This inherent complexity makes the models computationally heavy.

An IST project entitled Crossgrid examined the potential of grid computing to improve the performance of air pollution models. Grid computing takes advantage of distributing computing resources to provide benefits such as decreased model runtimes.

The Universidade de Santiago de Compostela used components developed during Crossgrid to adapt the sulphur transport Eulerian model 2 (STEM-II) to the grid environment. New features, such as fault control with check pointing, were also incorporated and are accessible via a graphical user interface. A comparison with the non-gridded version of STEM-II highlighted significant progress with respect to pollutant dispersion. This in turn yielded important gains in resource management.

Energy utilities as well as local authorities stand to benefit from the model enhancements realised by the Universidade de Santiago de Compostela during Crossgrid.

Improving public transport in Lithuania

A new city public transport route in Lithuania and scheduled databases provided by the PIKAS software program have been designed. Additionally, influences of passenger flows on the public transport system have been studied.

The Vivaldi project has provided innovation and outcomes in several important fields. These include clean vehicles, access management, pricing strategies, stimulation of collective transport, new forms of vehicle use, goods distribution, soft measures and telematics.

Under these auspices, new public transport services came about in Kaunas, Lithuania. The aim was to improve the organisation and the quality of public transport services. Particular emphasis was given to social and environmental concerns of citizens.

A distinct channel of feedback is available from the passenger to the transport division at the city municipality. This assists with the constant supervision and evaluation of the PIKAS management system. The system has a digital map editor which can directly register on the map all bus stops as well as crossroads and sections of streets. Since data from the main program, which are viewed in the tables, can be copied and pasted in Windows, it is quite user-friendly for transport specialists.

Handbook on participatory river basin management

The Harmonicop project has produced a handbook covering public participation methodologies for the advancement of social learning in river basin management in the context of the Water Framework Directive (WFD).

The Harmonicop project focused on improving awareness of participatory river basin management in Europe and supporting the execution of the WFD on this issue. The project's research focused on three crucial facets of river basin management. These were scale issues, the function of information and information tools, and cultural, political and geographical influences.

After in-depth case studies were conducted in nine countries, a handbook was created on public methodologies for the implementation of the WFD. The handbook, entitled *Learning together to manage together — Improving participation in water management* is a complement to the *Guidance document on public participation.*

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The first draft of the handbook was derived from a questionnaire created for water managers engaged in the nine case studies from which followed an analysis of the results. The methodology for finishing the handbook was chosen and the storyboarding was advanced. An additional questionnaire was used for feedback collection primarily from Harmonicop stakeholders as well as potential readers.

A workshop which focused on the exchange of practical experience was organised in September 2004. In particular, the aim was to learn from the stakeholders about problems arising in their everyday tasks in order to choose what should be covered in the handbook. In 2005, two workshops took place, details of which completed the draft versions of the handbook.

It appears that the many steps involved in the process of creating the handbook will be put to use to improve implementation of the WFD and integrated water management. Other sectors such as environmental policy are likely to be influenced by the handbook's context and other handbook designers by its advanced participatory design approach.

Rescue remedy for water resources in Egypt

The Abu Qir bay region of Egypt is an area of great historical value combined with large areas of fertile agricultural land. Scientists have prepared a report to highlight problems due to unplanned development in the area.

In Abu Qir, a small fishing town, one can sunbathe on the beach, fish, swim and eat fresh seafood. Abu Qir is also the home of many historical sites dating from the Egyptian, Greek and Roman dynasties. But at El Tabya pump station, about 2 million m³ of industrial waste water are pumped into Abu Qir bay every day. Needless to say, these two facts epitomise the potential and the problems of the region.

Widespread development of the Mediterranean coasts generally provided the catalyst for the EU-funded SMART project to explore methods for long-term sustainable resource management policy. The statistics collected and subsequent recommendations can then be utilised to manage and balance resources between the coastal and inland areas. Project partners at the Centre for Environment and Development for the Arab Region and Europe (Cedare) in Cairo chose to concentrate specifically on the often-polluted water resources in the area of the Abu Qir bay region.

The whole area includes not only the bay itself but the Rosetta branch of the River Nile, Lake Edku, and is bounded on the south side by the Mahmoudia canal. The ancient city of Alexandria with its approximately 4 million inhabitants relies on its freshwater supply from the canal which emanates from the Rosetta branch of the Nile. Development, a lot of which is unplanned, is industrial, agricultural and domestic in its source. With its fertile plains that form valuable productive land and the host of archaeological sites, the region is considered to have a wealth of undeveloped potential. However, lack of planning, awareness and sustainable management strategies have rendered a situation where the environment is damaged and degraded.

The team at the centre used state-of-the-art technologically advanced tools to study all aspects of the area. These included remote sensing, geographic information systems and water resource modelling involving both quantitative and qualitative measurements. These were used to formulate an integrated plan for sustainable development that includes all aspects of water supply limitation and its causes. These range from inadequate infrastructure to lack of awareness of involved parties in industry, government and the public at large.

Implementation of the findings of this report may well contribute to halting the rapid decline of the water quality in the area. Stemming the pollution and cleaning up the resource can then lead to increased development of the area. Interested parties can access the project website at: http://www.ess.co.at/SMART

Modelling climate change

Technological change should generally lead to the substitution of obsolete and dirty technologies with cleaner ones. Climate models do not consistently reflect this, showing us that technical change is not per se always environmentally friendly.

Climate models are the main quantitative tools designed either to depict long-run energy and pollution scenarios or to assist in climate change policy analysis. This modelling has traditionally accounted for the presence of technical change, albeit usually evolving in an exogenous fashion. More recently, however, models have been proposed where the technology changes endogenously, or where its change is induced by deliberate choices of agents and government intervention.

Research conducted by a team at Fondazione Eni Enrico Mattei in Italy as part of the Transust project suggests that we have now moved or are moving toward an endogenous and induced formulation of technical change. In particular, both bottom-up and top-down models, a long-standing distinction in energy-economy-environment modelling, have been recently modified in order to accommodate forms of endogenous technical change.

The researchers focus on these issues in a paper which provides insights delivered by the improved modelling approaches.

The objective is to enable policy-makers to define policies which strengthen sustainable development.

The project as a whole sets out to identify the concept of welfare generating services, for example mobility, housing or information, by investigating the drivers that determine the ratio and relationship between the stock and flow variables. It approaches these objectives by preparing a set of cross-cutting papers.

These comprise a standardised questionnaire which was created and for which all partners provided inputs. For a wide range of models, their reaction with respect to different carbon tax intensities and tax recycling options are analysed. The model-by-model results of this questionnaire are laid down in this cross-cutting paper and made available on the project website at: http://www.transust.org

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Improved humidity extraction

A dehydrator unit has been created to extract the internal humidity of a photovoltaic concentration system.

The CAC project has designed a controlled atmosphere concentrator (CAC) that uses an innovative line focus reflective concentration module concept. It consists of a box containing the key components of photovoltaic concentration modules, which are photovoltaic cells and reflectors. The novel system is able to get rid of degradation problems associated with reflectors in systems of this type by encapsulating the necessary organic elements.

The CAC system involves humid air crossing a humidity sensor which is then transported to the entrance of the compressor via the electro-valve and air filter. Air exiting the compressor is passed into a homogeniser of pressure which transforms the sporadic flow into continuous flow. The process involves crossing a filter of salts provided with an element heater, then crossing another filter of salts where humidity reten-

tion is completed via a valve of on-pressure and an electro-valve to the CAC. Once the salts have absorbed most of the humidity, a regeneration process starts. This activates the two electro-valves in order to transport air circuits and feed the electro-heater with the first filter of salts.

Case studies of urban water supply

Sustainability assessments of urban water resources and systems were conducted through case studies in four cities.

With the assistance of computer tools, the AISUWRS project analysed a variety of current urban water supply and disposal scenarios. This was achieved through demonstrating the ways in which each scenario differs in terms of contaminant handling. The extent to which such contaminant loads are able to pollute groundwater was estimated.

Detailed field studies were then conducted in four case study cities in order to verify and validate the model. The cities included in the case study were Doncaster in the United Kingdom, Gambier in South Australia, Ljubljana in Slovenia and Rastatt in Germany.

Due to certain problems such as scarce data availability, it was not possible to implement

the entire range of the approach. Furthermore, the final decision workshop could not be applied because action scenarios were found irrelevant and also because results concerning the impact of improvement measures were delayed.

ENVIRONMENT

Space applications for environmental monitoring

Improved methods for retrieving snow parameters from earth observation data that could subsequently be employed for hydrological modelling of snowmelt run-off and flood forecast have been developed by the Envisnow project.

Snow and glaciers play an important role in the water cycle at high latitudes, as well as in mountainous regions and the river system they drain into. Numerous hydrological models have been developed to estimate the amount and timing of snowmelt run-off from snow and glaciers in the mountainous areas of Northern Europe. However, a major drawback to the use of these models has been the insufficient information available on the spatial and temporal distribution of their key parameters.

By exploiting the unique potential of combining data from multiple sensors aboard the European Space Agency's environmental satellite Envisat, the Envisnow project sought to provide a better understanding of these complex earth processes. Under the coordination of Norut Information Technology,

existing techniques were investigated, and importantly new multitemporal algorithms were proposed for the regional mapping of important input parameters for hydrological models. More specifically, synthetic aperture radar (SAR) repeat pass imagery data were used to derive dry snow above areas with wet snow and thus support the mapping of the whole snow-covered area.

The use of weather- and light-independent data from the advanced synthetic aperture radar (ASAR) allowed continuous coverage of both high spatial and temporal resolution, comparable to products of optical imagery. Furthermore, to improve the differentiation between wet snow characterised by low radar backscattering and dry snow or bare ground, air temperature data from meteorological station networks

were required. High-resolution surface air temperature maps were created and used to filter wet snow from reference images captured during cold, dry snow conditions and subtracted from the image to be processed.

Maps of snow-covered mountainous areas of southern Norway have been derived for the spring melt season and validated against images from the medium-resolution imaging spectrometer (MERIS) and field observations. Finally, a production line for near-real-time automated geocoding of ASAR images and classification of snow-covered areas was established for use in operational applications for sustainable management of the environment.

Plant responses to global environmental change

The responses of terrestrial ecosystems to global environmental change and the resulting impact on the natural resources on which humans depend were the key issues addressed within the Vulcan project.

Anthropogenic emissions of greenhouse gases are expected to raise the mean temperature of the earth's surface by 1.4 to 5.8 °C during this century. Corresponding changes in air and soil temperatures, soil water and nutrient contents as well as in concentrations of atmospheric carbon dioxide are likely to alter the way in which natural and managed ecosystems function.

More specifically, predicted changes in climate may affect key soil processes such as respiration and nitrogen mineralisation, and thus key ecosystem functions, including carbon storage and nutrient availability. To identify the sensitivity of shrubland soil to these predicted changes, experimental manipulations at field scale were carried out by scientists of the Università degli Studi della Tuscia in Italy.

These experimental manipulations involved ecosystem warming and prolonged summer drought in ericaceous shrublands across Europe. Warming was anticipated to affect the decomposition of organic matter in the soil. Increased turnover of the organic matter pool would be reflected in changes

in the soil water composition; especially an increase in nitrogen content may be expected.

Overall vegetation growth had increased in northern sites, which tend to be temperature-limited, primarily due to the increase in biomass of dominant shrub species. Continued monitoring enabled scientists to detect whether the increased plant production was a transitory effect, or a new equilibrium. It was concluded that the increased plant production was the result of both direct (climate) and indirect (nutrient availability) causes.

Soil studies demonstrated an increase in the availability of nitrogen in both warming and drought treatments. On the other hand, carbon storage in the soil was found to be determined by the balance between carbon inputs (litter) and carbon lost

through soil microbial activity and root respiration.

The differences in important ecosystem processes among different sites could furthermore indicate the long-term consequences of climate changes. They may also serve as a powerful tool to evaluate the sensitivity of terrestrial ecosystems under different climatic conditions. More importantly, the Vulcan project research can support management practices to sustain the quality of these ecosystems in Europe.

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Monitoring landslide-prone areas

For the spatial optimisation of landslide alert systems, a multi-scale approach has been introduced to reduce the areas of active and potential landslides that need to be observed step by step.

The impacts across the globe of extreme natural events such as landslides are enormous, and a serious handicap to the advancement of societies struggling to achieve sustainable development. Too often those at risk do not have proper early warning of the events nor are they properly equipped to respond to available warning information.

Landslide hazard mitigation strategies should comprise a wide range of activities, including mapping of hazard zones, real-time monitoring and alert systems for active landslides, protective engineering measures and emergency planning. Against this background, the OASYS project sought to collect as much information as possible from different disciplines, which could be used within a knowledge-based system to define landslide risk.

Due to the combination of topographical, geological and seismological conditions, landslides are a common phenomenon in

northern Greece, where the site investigated by project partner Egnatia Odos S.A. is located. The Greek test site Prinotopa was identified as a landslide-prone area from remote sensing data with the use of differential synthetic aperture radar (SAR) interferometry. The geomorphology of the Prinotopa landslide further indicated that in the past there had been landslides of significant extent, and this was also confirmed by the available geological data.

In a first step, geodetic deformation measurements were carried out to collect information on block movement and on the boundaries between stable and unstable areas. In the following step, high-precision geotechnical measurement systems were installed across the boundaries between unstable areas moving with different velocities in different directions. This multisensor network, consisting of inclinometers, extensometers, piezometers and a rain gauge, was logging data continu-

ously from 2002 to 2004, and therefore could support a real-time alert system.

All the information collected was made available for use within the knowledge-based system proposed by the OASYS project to assess further development of the sliding area. This system could lead the practitioner from data acquisition to the definition of landslide risk and suggestions for risk management measures.

Shrubland management guidelines

An end-user group (EUG) has produced guidelines for shrubland management and information dissemination.

Shrubland ecosystems in Europe are susceptible to numerous environmental stress factors. For example, climate change causes increased night-time temperature, more intense rainstorms and prolonged droughts. Such stress factors may well create negative consequences on the ecosystem function of shrublands in Europe.

Under these auspices, the Vulcan project examined these effects via experimental manipulations of six shrubland ecosystems in Europe. Furthermore, it analysed the

effects of warming and drought on plant, soil, fauna and soil water processes. Using the obtained results and current knowledge of how management affects shrubland ecosystems, a sophisticated system was designed to create vulnerability scenarios for shrublands. Management actions could thus be evaluated and ranked.

Ultimately, the results were made accessible to end-users and decision-makers in order to create a broader focus on dissemination and relevancy to society. This makes it possible

to transfer knowledge on the implications of climate change to potential shrubland end-users, land managers, nature conservationists and decision-makers. Managers are thus able to heed warnings and take appropriate necessary measures. Through targeting and prioritising management, the vigour of shrubland ecosystems can be enhanced. As a way to branch out to a wider span of end-users, a website was also established.

Reforestation for life

Soil erosion, as well as a series of catastrophic ecological phenomena that accompany it, poses significant risks to global ecosystems.

Reversing processes such as soil erosion and reclaiming saline soils under arid conditions are challenging tasks. Reforestation under strict regimes has been shown to act beneficially in these ecosystems, although much care is needed in the choice of plant species. The EU-funded Establish project sought to identify stress-tolerant tree species through a number of molecular and genetic steps and achieve cost-effective reforestation methodologies where they are needed most.

Project partners Instituto Superior de Agronomia in Portugal focused on the *Populus alba* species, commonly known as the white poplar. Researchers developed innovative, optimal procedures for watering white poplar plants in semi-arid regions. A drip irrigation system was used to achieve contrasting conditions of water availability among the plant population.

This method allowed plants to grow under a variety of conditions and respond favour-

ably to high and low water stress. At the same time, researchers also developed protocols for the measurement of root growth capacity, applicable to a variety of *Populus* species. These new approaches could provide the blueprint for a radical innovation in the way land masses are treated in arid and semi-arid climates.

Unlocking the secrets of the global carbon cycle

Scientists with the Max Planck Institute for Biogeochemistry turned to space for answers regarding the exchange of carbon between sources and sinks in the biosphere.

Improving our understanding of the global carbon cycle will provide insight into the mechanisms driving climate change. Surface fluxes of carbon dioxide (CO_2) are an important component of the global cycle. Measurement of these fluxes over large areas is experimentally challenging; hence, scientists often rely on data collected from sensors aboard earth-orbiting satellites.

The COCO project was designed to take advantage of data provided by Envisat, the European Space Agency environmental satellite, and other recent missions. The project spanned nearly four years and received funding of approximately EUR 1 million from the EESD programme. The COCO consortium was led by the Max Planck Institute for Biogeochemistry.

One of the main objectives of the project was to improve the accuracy of column measurements of CO_2. The COCO scientific team endeavoured to reduce the measurement uncertainty to below 1 %. This involved a detailed investigation of complex variables concerning sensor operation, satellite orientation and so forth in an effort to eliminate possible sources of error.

The new column measurements will be validated against field data collected from the existing surface-based network. The achievements of the Max Planck Institute for Biogeochemistry and its partners have been summarised and published.

Assessing India's peri-urban needs

The word 'peri-urban' refers to the expanse of land or region located on the outskirts of a city or town. Efforts have been taken to better understand this setting along with its diversity and policy challenges, with particular regard to energy and transport.

Although it is quite well known that urbanisation significantly contributes to land-use changes and degradation of natural

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resources, an impact assessment had not been adequately explored until now. Thus, the Periurban project has sought to identify inner links between socioeconomic and environmental processes and to comprehend current institutional mechanisms. Furthermore, pressures placed on natural resources caused by energy consumption and transport were also examined.

Geoscientists took a multidisciplinary approach to impact assessment techniques which will be useful to the communities in developing countries. A policy workshop in Delhi, India, in September 2005 generated many important findings regarding what peri-urban policy needs to entail. Among these were pointers on what should make up the basic elements. Topics included were sustainability, reliance on community-based budgeting, flexibility and diversity, a pro-poor and gender-sensitive element and reliance on participatory methodologies. Also included were policy options for energy in the peri-urban interface.

The knowledge obtained has been disseminated in both technical and non-technical formats. As a result, these efforts should make a positive impact on food security, health and overall quality of life, hence contributing to the sustainable economic, social and scientific development of India.

Helping Alpine farmers

Despite the sector's decline, farmers have resorted to different strategies to ensure that agriculture remains dynamic in the Alps. Promoting sustainable agriculture at the local level is the aim of the IMALP project.

The promotion of sustainable agriculture in the Alpine mountains is becoming increasingly important to the region's citizens and administrators. Agriculture has a strong presence throughout the Alps, despite its decline in recent years, and supporting this sector is considered vital to its economy and community.

The IMALP project has been concerned with developing practical advice on deploying collective actions that are implemented at the local level in the region. It produced a handbook for local activists, advisory services, training institutions and administrators in the field of agriculture and rural development. It stresses the importance of improving the quality of the products originating in the region and supporting the role agriculture plays in rural development.

The handbook differs from previous literature on the subject in that it places its focus on implementing actions, whereas other guides have limited themselves to the designing phase of such actions. Furthermore, it has placed great importance on the involvement of a broad variety of actors and institutions in the project.

The project itself set out as one of its overall goals to place farmers at the epicentre, by giving them the opportunity to manage with a new form of local governance. It presented the implementation of a consistent set of actions in favour of sustainable agriculture and rural development. Preparing farmers to participate in groups addressing rural development helps them realise their empowerment to play a more active role and highlights agriculture's importance for the future of a particular area.

Beating the codebreakers with quantum cryptography

Quantum cryptography may be essentially solved, but getting the funky physics to work on disciplined computer networks is a whole new headache.

Cryptography is an arms race, but the finish line may be fast approaching. Up to now, each time the codemakers made a better mousetrap, codebreakers breed a better mouse. But quantum cryptography theoretically could outpace the codebreakers and win the race. Forever.

The current state of the art in classical encryption, 128-bit RSA, has thus far remained immune to brute force attempts to crack it. But 128-bit encryption is vulnerable during key exchange, when the code is actually established, and to other forms of attack.

Those vulnerabilities will only get worse with the advent of quantum computing, a still fledging science that uses the physics of the sub-atomic to perform operations on data much faster than current technology. Quantum cryptography solves the problem, and it will overcome the remaining stumbling block, the distribution of the code key to the right person, by using quantum key distribution.

Modern cryptography relies on the use of digital 'keys' to encrypt data before sending them over a network, and to decrypt them at the other end. The receiver must have a version of the key code used by the sender so as to be able to decrypt and access the data.

Quantum key distribution offers a theoretically uncrackable code, one that is easily distributed and works in a transparent manner. Even better, the nature of quantum mechanics means that if any eavesdropper — called Eve in the argot of cryptographers — tries to snoop on a message, the sender and receiver will both know.

That ability is due to the use of the Heisenberg uncertainty principle, which sits at the heart of quantum mechanics. The principle rests on the theory that the act of measuring a quantum state changes that state. It is like children with a guilty secret. As soon as you look at them, their faces morph plausibly into 'Who, me?'

The practical upshot for cryptography is that the sender and receiver can verify the security of the transmission. They will know if the state of the quanta has changed, whether the key has been read en route. If so, they can abandon the key they are using and generate a new one.

Quantum key distribution made its real-world debut in the canton of Geneva in the context of the electronic voting system used in the 2007 Swiss general election. The system guaranteed that the poll was secure. But, more importantly perhaps, it also ensured that no vote was lost in transmission, because the uncertainty principle established that there was no change to the transmitted data.

The canton election was a demonstration of the work done by researchers for the Secoqc project, an EU-funded effort to develop an international network for secure communication based on quantum key distribution.

The test of the technology demonstrated that quantum key distribution worked for point-to-point communications between two parties. But the demonstration was just the beginning of Secoqc's overall goal.

'We want to establish a network-wide quantum encryption, because it will mean it works over much longer distances,' explains Dr Christian Monyk, coordinator of the Secoqc project and head of the quantum technologies unit at the Austrian Research Centres. 'Network quantum encryption and quantum key distribution mean that many parties can communicate securely, not just two. Finally, it also means quantum encryption could be deployed on a very large scale, for the insurance and banking sectors, for example.'

Moving the system from point-to-point communications to a network is an order of magnitude more difficult.

'The quantum science for cryptography and key distribution is essentially solved, and it is a great result,' Dr Monyk says. 'But getting that system to work across a network is much more difficult. You have to deal with different protocols and network architectures, develop new nodes and new interfaces with the quantum devices to get it to a large-scale, long-distance, real-world application.'

Getting the system to work over long distances is also a challenge because quantum key distribution requires hi-fidelity data transmission over high-quality physical networks like non-zero dispersion shifted fibre optics. 'It was not one big problem, it was many, many small computing science and engineering problems,' says Dr Monyk. 'We had to work with a large number of technologies. And we have to certify it to experts.'

But Secoqc's researchers believe they have solved the network issue. The researchers are currently putting the final touches to a demonstration of the technology to be held this October in Vienna, Austria. Industry has shown great interest in the technology. Still, the technology is not quite ready for prime time.

'From a technical point of view, the technology will be ready in one or two years,' says Dr Monyk. And that means that the race will be won, finally, by the codemakers.

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Piecing together the next generation of cognitive robots

European researchers are making progress on piecing together a new generation of machines that are more aware of their environment and better able to interact with humans.

While building robots with anything akin to human intelligence remains a far-off vision, making them more responsive would allow them to be used in a greater variety of sophisticated tasks in the manufacturing and service sectors. Such robots could be used as home helpers and care givers, for example.

As research into artificial cognitive systems (ACSs) has progressed in recent years, it has grown into a highly fragmented field. Some researchers and teams have concentrated on machine vision, others on spatial cognition and on human-robot interaction, among many other disciplines. All have made progress, but, as the EU-funded 'Cognitive systems for cognitive assistants' (CoSy) project has shown, by working together the researchers can make even more advances in the field.

'We have brought together one of the broadest and most varied teams of researchers in this field,' says Dr Geert-Jan Kruijff, the CoSy project manager at the German Research Centre for Artificial Intelligence. 'This has resulted in an ACS architecture that integrates multiple cognitive functions to create robots that are more self-aware, understand their environment and can better interact with humans.'

The CoSy ACS is indeed greater than the sum of its parts. It incorporates a range of technologies from a design for cognitive architecture, spatial cognition, human-robot interaction and situated dialogue processing to developmental models of visual processing. 'We have learnt how to put the pieces of ACS together, rather than just studying them separately,' adds Dr Jeremy Wyatt, one of the project managers at the United Kingdom's University of Birmingham.

The researchers have made the ACS architecture toolkit they developed available under an open-source licence. They want to encourage further research. The toolkit has already sparked several spin-off initiatives.
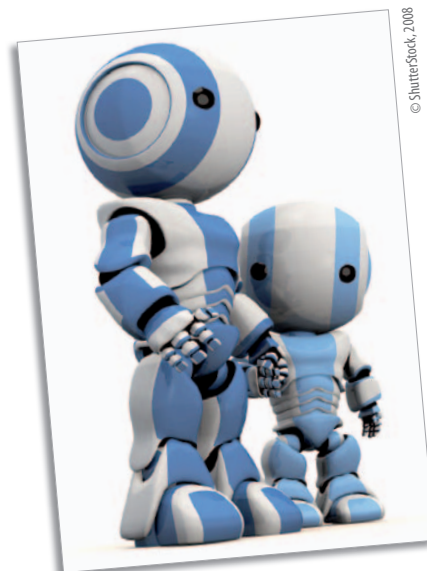
'The integration of different components in an ACS is one of the greatest challenges in robotics,' Dr Kruijff says. 'Getting robots to understand their environment from visual inputs and to interact with humans from spoken commands and relate what is said to their environment is enormously complex.'

Because of the complexity, most robots developed to date have tended to be reactive. They simply react to their environment rather than act in it autonomously. Similar to a beetle that scuttles away when prodded, many mobile robots back off when they collide with an object, but have little self-awareness or understanding of the space around them and what they can do there.

In comparison, a demonstrator called the Explorer developed by the CoSy team has a more human-like understanding of its environment. Explorer can even talk about its surroundings with a human. Instead of using just geometric data to create a map of its surroundings, the Explorer also incorporates qualitative, topographical information. Through interaction with humans, it can then learn to recognise objects, spaces and their uses. For example, if it sees a coffee machine, it may reason that it is in a kitchen. If it sees a sofa, it may conclude it is in a living room. 'The robot sees a room much as humans see it, because it has a conceptual understanding of space,' Dr Kruijff notes.

Another demonstrator, called the PlayMate, applied machine vision and spatial recognition in a different context. PlayMate uses a robotic arm to manipulate objects in response to human instructions.

In Dr Wyatt's view, the development of machine vision and its integration with other ACS components is still a big obstacle to creating more advanced robots, especially if the goal is to replicate human sight and awareness. 'Don't underestimate how sophisticated we are …,' he says. 'We don't realise how agile our brains are at interpreting what we see. You can pick out colours from a scene, look at a bottle of water, a packet of cornflakes or a coffee mug and know what activities each of them allows. You recognise them, see where to grasp them, and how to manipulate them, and you do it all seamlessly. We are still so very, very far from doing that with robots.'

Fortunately, replicating human-like intelligence and awareness, if it is indeed possible, is not necessary when creating robots that are useful to humans. Dr Kruijff foresees robots akin to those developed in the CoSy project becoming an everyday sight over the coming years in what he describes as 'gofer scenarios'. Already some robots with a lower level of intelligence are being used to bring medicines to patients in hospitals and could be used to transport documents around office buildings.

Robotic vacuum cleaners are becoming increasingly popular in homes, as too are toys that incorporate artificial intelligence. And the creation of robots that are able to interact with people opens the door to robotic home helpers and care givers. 'In the future people may all be waited on by robots in their old age,' Dr Wyatt says.

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Towards high-definition telepresence

Tactile and kinaesthetic displays are the fundamental technical elements of the virtual tactile environment developed to recreate the haptic modality of human perception.

Technological innovations leading to high-fidelity recordings and synthesis of natural signals for stimulating the human sensory system have transformed the modern way of life. However, the full sensation of presence in a virtual environment requires tactile and kinaesthetic feedback, in addition to audio and visual information. More importantly, tactile feedback can improve the human tactile perception in modern telemanipulation systems.

In order to advance human-computer interfaces (HCIs) beyond mere multimedia applications, the limits of current technologies have been significantly extended within the Touch-hapsys project. Non-mechanical physical principles such as magnetic and electric fields were exploited for force generation, along with new mechanically active materials, including polymeric gels, artificial muscles and biomolecular actuators.

Project partners' research work, under the coordination of Technische Universität München, led to the development of a powerful hand/arm kinaesthetic display to provide spacious force feedback to the operator's hand. Due to its hyper-redundant joint design, 'Virtual scenario haptic rendering device with 10 degrees of freedom' (Vishard10) offered a large workspace and a maximum payload, which was sufficient to attach additional haptic displays.

As the influence of forces tangential to the fingertips plays an important role in the tactile exploration of objects, a novel sphere-based tactile slip friction display was mounted on Vishard10. To provide individual force stimuli tangential to the surface of the human skin in the area of the fingertip, Vishard10 was further connected with a tactile shear force display.

For smaller scale features, like pointedness and texture of solid objects, not displayable with a kinaesthetic feedback alone, tactile information could be provided through a matrix of stacked piezo-actuators. The modular integration of a kinaesthetic display and several tactile displays in serial configuration provided a versatile experimental set-up to improve the current understanding of the haptic modality of human perception.

Besides the various possible telepresence and virtual reality applications, the integrated haptic devices could provide a robust tool for investigating the psychophysical basis of human kinaesthetic and tactile perception.

Sense of touch

Electronic integrated environmental systems have a wide range of applications. In order to use the biological principles of sensory receptor and nervous system function as an input, researchers have investigated tactile and visual processing in human neural systems.

The interpretation of stimulatory input from our environment creates images of our environment on which we can base our actions, thoughts and automatic responses. This amazingly complex process can easily be taken for granted until the loss of a sense occurs.

The aptly named Sensemaker project formulated its main aim as the creation of electronic devices with sensory information input from different modalities. Processing the information would then provide the user with a representation of their environment. Like the brain, able to extract the relevant information from the sensory representations, the software platforms would be able to selectively process information from modalities. Project partners focused on vision, audition and the haptic sense, or sense of touch, with an internal motor command facility.

As part of the biological component of the project, partners at Trinity College Dublin in Ireland chose to investigate the tactile sense and its mode of interpretation in the brain. How the central nervous system actually processes sensory information would be a crucial feature in the design of software for the project. It is known, for example, that the visual sense operates on a dual basis, one for spatial processing and the other for recognition. The team used both behavioural parameters and functional magnetic resonance imaging (fMRI) to investigate responses to unfamiliar stimuli.

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Results from the MRI scans showed that haptic information occupied a shared network of areas in the cortex. Overall, however, spatial information is dealt with by the occipito-parietal pathway, but recognition is processed by the occipito-temporal pathway. Behavioural tests supported these conclusions and showed that the two functions are task dependent and do not interfere with each other. Interestingly, vision was found to have an effect on tactile spatial and object recognition, and when visual information is reduced, there is an enhancement of behavioural performance by a combination of the two senses.

In conjunction with the Electronic Vision Group at the Kirchhoff-Institut für Physik in the University of Heidelberg, the team from Dublin developed the virtual haptic display (VHD) device. The innovative feature in respect of the predecessor model is that it does not rely on passive input but needs active exploration. The image is displayed either as a whole or part by means of a controllable aperture.

Potential applications of this technology cover a wide range. Patients with impaired sensory perception stand to benefit. Learning aids could also be improved, as could current methods of environmental analysis and depiction in hazardous situations. For now and the future, there are obvious applications in cognitive robotics, autonomous systems and distributed intelligence.

IT AND TELECOMMUNICATIONS

Algebraic geometry as a source of inspiration for designers

Computer-aided design (CAD) tools are making it possible to automate many aspects of the design of engineering and architectural solutions. Enhanced two- and three-dimensional modelling capabilities could be offered with the use of effective and efficient algorithms and corresponding software structures developed within the 'GAIA II' project.

By manipulating simple shapes, including lines, circles and arcs, polygons and rectangles, designers can construct realistic models of solid objects. CAD tools allow for the combination of simple shapes into more complex ones through union, intersection and difference operations.

Parametric description of solid objects with the use of rectangular, non-uniform rational basis spline (NURBS) surfaces sharing the same boundaries is implemented by very stable numerical algorithms. On the other hand, implicit representations originating from algebraic geometry offer attractive alternatives for reconstructing surfaces from unstructured point clouds without assuming the existence of an initial data parameterisation.

The numerical methods developed within the European project 'GAIA II' provide for the simultaneous availability of both representations, which is desirable for computing surface intersections. To fully exploit the potential of both representations in challenging applications where surfaces intersecting are parallel or near parallel, approximate methods were preferred for the conversion between them.

Furthermore, numerical techniques for approximately converting implicitly defined surfaces into parametric ones and vice versa were implemented as a prototype software toolkit, combining recursive subdivision and approximate implicitisation. Besides supporting the identification of all the inter-section's branches within a user-defined tolerance, this experimental code provides for the refinement of the intersection curves to the accuracy required.

Research work at the Sintef ICT laboratories in Norway focused on CAD operations (such as offsetting and blending) which produce surface intersections with singularities. The combination of the two representations offered the possibility to detect not only singularities but also self-intersections, which need to be removed in order to maintain the model's correctness.

As the approach adopted is aimed for use in industrial applications, the suitability of the algorithms as well as the stability of the software toolkit is a subject of further research.

Designing bug perception into robots

Insects have provided the inspiration for a team of European researchers seeking to improve the functionality of robots and robotic tools.

The research furthers the development of more intelligent robots, which can then be used by industry, and by emergency and security services, among others. Smarter robots would be better able to find humans buried beneath the rubble of a collapsed building, for example.

The EU-funded SPARK project set out to develop a new robot control architecture for roving robots inspired by the principles governing the behaviour of living systems and based on the concept of self-organisation. Basing their work on the basic functions of the insect brain, the team developed a new architecture for artificial cognitive systems that could significantly increase the ability of robots to react to changing environmental conditions and to 'learn' behaviour in response to external stimuli. The research team calls its new software architecture a spatial-temporal array computer-based structure (SPARC).

Robots are complex systems that rely on software, hardware and mechanical systems all working together. One of the challenges facing researchers is to develop robots, or moving artefacts, that are capable of several different behaviours, that are able to sense or perceive external signals and, most importantly, are able to 'learn' and react appropriately to changing conditions. For example, a robot travelling over unknown terrain may need to adapt its way of moving depending on whether it is navigating flat, rocky or wet ground. Or it may need to modify its course to reach a defined target.

The objective is to enable a robot to do this without human intervention, based on its own powers of perception and ability to adapt. Within the SPARC software architecture, the robot's powers of perception are enhanced by its ability to use information derived from visual, audio and tactile sensors to form a dynamically evolving pattern. The pattern is in turn used to determine the movements of the device. The researchers' technical objective was to produce a moving artefact able to actively interact with its environment to carry out a set task.

The research so far has already provided a new theoretical framework, or paradigm, for active robot perception. The paradigm is based on principles borrowed from psychology, synergetics, artificial intelligence and non-linear dynamical systems theory.

One of the researchers' central objectives was to develop a machine with the ability to build knowledge independent of human control. Researchers based the proposed

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Cutting the costs of public address

Professional audio comes in a variety of guises. The most popular for small venues is the system of public address, yet cabling and installation costs for this remain high. Applying technology developed by the Wirenet project provides the solution.

Public address is used as a sound reinforcement system; it is able to distribute sound to the general public in and around buildings. Primarily, this system is used for speeches made in small venues such as churches and town halls. It requires the installation of cabling, which links all the parts of the system together. As well as the user needing a certain amount of technical knowledge for this, cabling makes up a substantial amount of the cost of using this system of professional audio. Research conducted by the Wirenet project has shown that its technology can be used with public address to drive down cost.

Dunvegan Networks, a limited company based in Liverpool in the United Kingdom, has been active in the field of professional audio, in particular in audio conferencing and public address systems. Dunvegan is involved with one of the Wirenet project demonstrators which are intended to demonstrate the feasibility of using medium data rate Wirenet technology to transmit multiple channels of audio via mains power cables. They have long observed the need for this solution.

With a successful demonstration of the concept for this application, Dunvegan will develop commercial versions of their systems. It will also exploit the Wirenet results by distributing the standard Wirenet modules within English-speaking countries.

The Wirenet technology can, when developed into products, contribute to the design of devices to be used in industry and by the consumer which are cheaper than the current solutions offered. Developing cheap technology for the transmission of such information is going to make a significant difference in the use of home appliances, amongst other things.

architecture for artificial cognitive systems on the basic building blocks of the insect brain. 'The SPARC architecture is a starting step toward emulating the essential perception-action architecture of living beings, where some basic behaviours are inherited, like escaping or feeding, while others are incrementally learned, leading to the emergence of higher cognitive abilities,' notes Professor Paolo Arena, the project coordinator.

The cognitive system allows the device to autonomously 'learn' based on a combination of basic reflexive behaviours and feedback from external environmental data.

Once the robot is assigned a mission, compatible with its structural and mechanical capabilities (for example, 'find people alive'), it is able to work out how best to do this itself in a particular external context.

'The robot will initially behave by using primarily the basic inherited behaviours,' Professor Arena says. 'Higher knowledge will be incrementally formed in the higher layer of the architecture, which is a neuron lattice based on the reaction-diffusion cellular non-linear network (RD-CNN) paradigm, able to generate self-organising dynamic patterns.'

Basic behaviours incorporated in the demonstrations so far include, for example, the ability of a robot to direct itself towards a specific sound source. This optomotor reflex allows the robot to maintain heading and avoid obstacles.

During the course of the demonstration, the robot 'learns' how to safely reach the sound source. This it does while it is properly modulating its basic behaviours so it does not become trapped into the deadlock situations that are typical of complex and dynamically changing environments.

The project's experimental robots used some of the partners' technologies, such as the real-time visual processing features of the Eye-RIS vision system, one of the lead products of Spain-based Innovaciones Microelectrònicas (Anafocus).

The project also attracted the interest of other commercial enterprises, including STMicroelectronics, which provided components and boards for Rover II, one of the robots developed by SPARK. Altera, another company, supplied field-programmable gate array (FPGA) devices for the development and implementation of perceptual algorithms.

The advances made have led to a number of software and hardware innovations for the improvement of machine perception. The project's industrial partners are continuing to work on the innovations. The cognitive visual algorithms designed and improved by the researchers have, for example, already been integrated into products produced by some of the project's partners. Hungary-based Analogic Computers, a partner in the project, has launched its InstantVision software package based on some of the research. The package has become one of the company's lead products.

The work of the SPARK project is continuing with the 'SPARK II' project, which will look more deeply into the details of insect brain neurobiology to refine, assess and generalise the SPARK cognitive architecture. Further down the line, the research is expected to lead to the introduction of powerful and flexible machines suitable for use in dynamically changing environments where conditions are unstable or unpredictable, such as war zones or disaster areas.

The project has introduced a new model for action-oriented perception. Ongoing work will focus on assessing this model and on expanding it to a larger family of moving machines. The SPARK project received funding from FP6.

IT AND TELECOMMUNICATIONS

IT AND TELECOMMUNICATIONS

Adaptive modulation for wireless communication systems

With the expected development of new multimedia services over wireless networks in the coming years, radio systems will have to meet demands for variable and higher data transfer rates. Requested at all different levels of mobility, enhanced adaptability to the actual transmission situation will be necessary.

Multi-antenna systems for both transmitter and receiver are currently being intensively investigated due to their ability to provide higher throughput with improved bit error performance over single-input and single-output systems. Orthogonal frequency division multiplexing (OFDM) may further be employed in the antenna arrays to increase diversity gain on time-variant and frequency-selective wireless channels. OFDM has already proven its applicability in various standards for broadcast and point-to-point communications by allowing for easy adaptation to the channels' conditions due to its frequency granularity.

Within the European FLOWS project, an innovative OFDM transmission scheme for multiple-input and multiple-output (MIMO) systems, adaptive to the current channel situation at the transmitter side, was introduced. Information on the current channel situation at the receiver side is provided in practice by means of chan-

nel estimation and prediction techniques. On the other hand, channel knowledge at the transmitter site can only be guaranteed if there is a backward channel and therefore, such transmission was more of a theoretical interest.

If the MIMO transmission channel is quasi-static, all necessary information on channel parameters can be retransmitted back to the transmitter using a backward channel. With the available signal power optimally distributed over subchannels, this singular value decomposition (SVD) approach yields the best possible gain factors and, importantly, the overall performance is maximised. In situations where the user starts to move during the time of transmission and the transmission channel fades rapidly, transmission depends on the static nature of each channel. By always selecting the strongest signal among the detected ones, the newly proposed adaptive transmission scheme corresponds to a V-Blast scheme.

The price that has to be paid for the increased flexibility in dealing with transmission channel fluctuations is additional implementation complexity. Extensive simulations showed that while increasing the number of retransmitted parameters enhances the transmission channel's overall performance, further antennas and subcarriers would lead to a compromise between performance and complexity.

Funded under the FP5 programme IST (User-friendly information society).

Collaboration sought: further research or development support.

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Nanoresonators for high-resolution mass detection

The 'Nanomass II' project addressed a new perspective of biosensing due to the possibility of manufacturing devices at scales similar to those of biomolecules.

The advances of nanotechnologies have enabled the miniaturisation of microcantilevers widely used for sensor applications, which are based on the detection of surface stress changes as the response signal. Absorption or deposition of compounds on vibrating nanometre-sized cantilevers can be detected by monitoring the resonant frequency shift due to the added mass. The nanoresonator structures are excited

into lateral vibration by means of an AC/DC voltage applied between the suspended cantilever and a fixed parallel electrode. Changes in cantilever resonance frequency are observed as capacitance changes. As a result of the technological innovations pursued within the 'Nanomass II' project, a full system-on-chip was developed to eliminate parasitic capacitance introduced by the external bonding pads and wires.

Complementary metal-oxide semiconductor (CMOS) circuitry for excitation and read-out of cantilever deflection was integrated together with the cantilever by combining standard CMOS techniques with novel nanofabrication methods. Ultra-thin chromium nano-cantilevers were defined by electron beam lithography using a double-layered mask of resist material on a silicon chip. After the lift-off process, the nano-cantilevers were released from the substrate by advanced reactive ion etching. The resultant chromium nano-cantilevers were 3 µm long and their width measured less

than 90 nm. Alternatively, specific quartz stamps were employed to define nano-cantilevers on the CMOS substrate by nanoimprint lithography. The two different nanolithography processes were furthermore compared to evaluate their advantages and limitations in terms of dimension reduction, throughput and their compatibility with CMOS.

When manufacturing such nano-electromechanical systems (NEMS), detailed knowledge of their electrical and, more importantly, their mechanical properties is most relevant for their use as ultra-sensitive single molecule sensors. Local elastic properties of nano-cantilevers of different lengths were estimated by mechanically bending them with the tip of an atomic force microscope (AFM) and measuring their bending displacement. Accurate and quantitative descriptions of the nano-cantilevers deflection were deduced that can be used to estimate the required cantilevers' dimensions for achieving the best possible performance for the mass sensor.

Funded under the FP5 programme IST (User-friendly information society).

Collaboration sought: further research or development support.

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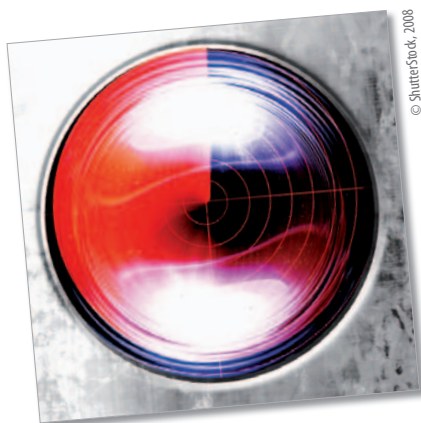
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Integrating embedded systems

Embedded digital control systems are powerful and ubiquitous in the technologies we use, but getting them to cooperate is difficult. That situation is changing.

Researchers at the EU-funded DECOS project say they have created tools to allow such embedded systems to operate more smoothly together, a benefit to industry and ultimately to users who depend on the technologies to operate in a safe and predictable manner.

The use of embedded system controls is increasing apace, with expensive cars containing up to 80 engine control units (ECUs). They can range from the simple, like the smarts in your digital watch, to the critical, like the fly-by-wire systems of modern jets. We entrust them with our lives in our cars and trains.

Already, embedded systems account for half of the revenue in the computing market, and almost every technical advance, from anti-lock braking systems to personal video recorders and avionics, relies on them.

The problem is that modern embedded systems often behave like individualists. This behaviour can be a result of the development process. Software can be the work of different programmers. Different manufacturers may develop the design specifications and interfaces. The result is federated, often autonomous modules that must cooperate to achieve an overall goal and to avoid ultimately endangering life or property.

The integrator — say, a car company or aircraft manufacturer — wants embedded systems to talk the same language using well-defined linking interfaces, and to perform in a predictable way under all circumstances. But this goal is complex and costly, and can often result in unreliable performance.

'The idea behind [our research] was to fight the growing complexity of distributed architectures,' says Dr Manfred Gruber from Austrian Research Centres (ARC), and co-ordinator of the DECOS project. 'Each new function in a car needs a new ECU, and creates a highly federated structure with maybe 70 ECUs or more.'

This situation means modern, cooperating embedded systems are difficult to develop, and very difficult to test and maintain. 'We want to reduce the number of necessary processors to a few, integrated systems,' says Erwin Schoitsch, project deputy coordinator, also from ARC. 'But if you integrate several applications — some safety critical, some not — you have to make sure they do not interfere with each other.'

The DECOS team sought to achieve these goals by developing a dependable middleware of high-level services based on several time-triggered core protocol services: time-triggered architecture, layered FlexRay and time-triggered Ethernet. These time-triggered protocols were developed to respond to safety-critical applications requirements, with a special focus on real-time applications. The development means lower costs and higher protocol efficiency and predictability.

DECOS developed the middleware architecture, components and tools for design, development, deployment, diagnosis as well as validation and verification. The project created a prototype tool-chain and test-bench, guiding the complete process, from model to deployment. The package includes

validation and certification support, as well as hardware and software components and basic software building blocks.

For example, the generic test-bench guides engineers through the verification and validation process, and supports a modular verification process. 'It provides a framework, with some new specific tools and the integration of existing external tools and safety standards,' Mr Schoitsch says.

To validate the approach, DECOS applied its results to three vital application fields for embedded systems: automotive, avionics and industrial control. These application demonstrators come with domain-specific tests and established the applicability of the DECOS middleware and tools.

DECOS' architecture for automotive systems works with such functions as adaptive lighting and door positioning. For industrial control, the DECOS architecture helped to suppress critical vibrations when nano-imprinting.

Within the aerospace domain, the DECOS team developed a demonstrator for a shift in airplane flap control. Flaps give an aircraft its lift at lower speeds. DECOS shifted the current state of the art — a mechanic synchronisation control — to all-electronic synchronisation. 'It's a long-term proposition, but we demonstrated that it was feasible,' Mr Schoitsch says.

Safety-critical avionics systems are a critical way to demonstrate the capabilities of the DECOS tools. But the project's results can be used anywhere, from trains to medical systems, mechatronics or robotics.

TTTech, one of the partners, developed and will now commercialise a time-triggered Ethernet system. The tool-bench has led to the development of another new product, which was integrated into the Certified Software Factory developed by Esterel Technologies.

DECOS also led to a spin-off by the Budapest University of Technology and Economics. Several spin-off and follow-up projects, such as Mogentes, again run by ARC, are planned.

The project took 42 months to complete, was funded with EUR 15 million and brought 18 of Europe's leading companies together. Global players such as Airbus, Audi, EADS, Fiat, Hella, Infineon, Liebherr Aerospace and Thales were involved.

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Beyond the CMOS scaling limit

Innovative memory devices developed within the SASEM project with the smallest ever possible number of electrons offer permanent storage of data while favouring low-power applications.

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Single-electron memory (SEM) devices are offering an attractive solution to the technological problems arising while approaching the complementary metal-oxide semiconductor (CMOS) scaling limit. Consisting of a nano-floating gate on a narrow-channel metal-oxide semiconductor field-effect transistor (Mosfet), they are still based on the conventional concept of 'charge transfer'. Not only compatibility with conventional CMOS technology is therefore ensured, but reusing the huge amount of know-how accumulated could address existing power dissipation problems.

The technology proposed by the SASEM project relies on implantation of arsenic to create a Gaussian profile of impurities in the active layer of a silicon-on-insulator (SOI) wafer. After defining the silicon mesa by lithography and dry etching, wet oxidation was performed to separate it into two wires with silicon oxide in between. The oxidation rate was increased in the presence of arsenic, while the variability of the silicon mesa width enabled the creation of a quantum dot on top of the continuous triangular channel. The quantum dot was charged/discharged by applying a negative/positive voltage to the gate respectively, and the induced change in drain current was used for readout.

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To ensure efficient control of the formation and size of the nano-floating gate, the entire device fabrication process was thoroughly investigated and simulated using the most reliable models. Critical process parameters such as oxidation temperature and time were subsequently optimised and reproducibility was guaranteed. The fabricated single-electron device has been tested for memory operations at room temperature, and the estimated performance characteristics are comparable to those of existing devices. While improvements are needed before the technology's industrial implementation, the feasibility of the device's down-scaling was shown and the use of quantum effects in practical devices has been brought closer.

Paving the way to 4G communication systems

An open mobile radio access network based on a new radio transmission principle, a complete ultra-wideband (UWB) system demonstrator, has been developed. Characterisation and measurements of a UWB radio channel have been performed.

Fourth-generation communications system (4G) is a label term for the future in wireless communications, where it is envisaged that multimedia data will be delivered at high speed to the user anywhere and anytime at premium quality with high security. At the moment, the United States are generally perceived to be closer technologically to realising this picture. The 'Ultra-wideband concepts for ad hoc networks' (UCAN) project intends to substantially aid in filling this technological gap between Europe and the United States by applying UWB technologies for communication, ad hoc networking and positioning.

Project partners have designed, developed and assembled a generic UWB platform that serves as the basis of an advanced, location-based, self-organising medium access control (MAC) and network (NW) layer scheme. The demonstrated ad hoc networking and positioning aspects are a potential component of the future 4G communication infrastructure. With the aid of the UCAN platform, a number of communication system experiments including multimedia applications have been performed.

Project partners have investigated UWB radio channel and performed UWB channel measurements and characterisation. For effective channel sounding and modelling, the set-up and the environment of the measurements have to be well defined. For the measurement set-up, the employed components and specifications (distances and frequencies) along with block diagrams and calibration procedures have been presented in detail. Accurate description of the different scenarios where the measurement campaigns were performed depicts the measurement environment. Distinguishing the transmission status of the communication as line-of-sight (LOS) and non-LOS (NLOS) is of great importance for the wireless communication systems. Thorough process analysis for both these channel models has been performed.

The current work on channel sounding and modelling, apart from being an integral and vital part of the project's internal research, is expected to provide more insight to the whole information research community.

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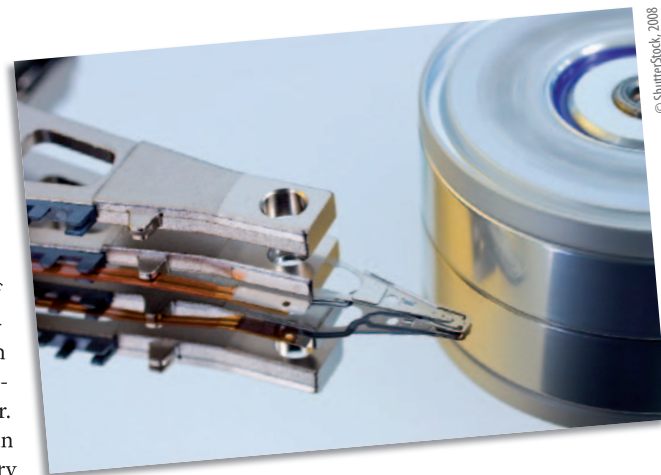
Innovative software for hip replacement modelling

A software system for the pre-operative planning involved in hip replacement has been designed.

Precise information on the way in which human anatomy functions both physiologically and pathologically is important in numerous medical fields as well as industrial realms like that of biomedical engineering. Although three-dimensional facets of functional anatomy are of primary significance, they are very difficult to present in a substantial manner. This means that the visualisaton and virtual manipulation of anatomical objects pose a challenge for testing innovative techniques.

In light of this, the Multisense project has delved into the visualisation of and interaction with data related to musculo-skeletal structures via multimodal and multisensorial interfaces. The aim was to design a user-friendly environment so that all the information can be shown through a set of representation-interaction pairs which allow biomedical professionals to achieve an enhanced effect.

HipOp_MS is such an environment. It is a flexible software system which is able to incorporate stereoscopic visualisation, non-stereoscopic visualisation, speech recognition system, tracking functionalities, haptic functions and innovative interaction paradigms. Furthermore, it can support musculo-skeletal modelling such as skin incision and muscle retraction as well as positioning of prosthetic parts.

Visualising speech technology

A framework which can swiftly create speech interfaces for use in visualisation software has been developed.

Having precise knowledge of human anatomy functions in both physiological and pathological conditions is vital in several medical fields, biomedical engineering being one such example. Of particular importance are the three-dimensional features of functional anatomy, but they are not easily represented in a coherent manner. Consequently, visualisation and manipulation of anatomical objects is an ambitious way to try out innovative methods.

In light of this, the Multisense project was concerned with the visualisation of, and integration with, data associated with musculo-skeletal structures through multimodal and multisensorial interfaces. A user-friendly visualisation and interaction environment has been created which presents all of the information through a set of representation-interaction pairs likened to medical imaging modalities obtained from biomedical professional uses.

By creating a new representation and interaction paradigm for virtual medical objects using multimodal and multisensorial interfaces, a speech framework was developed. It can connect with any speech recogniser supporting context-free grammar and any speech synthesis, and it is also compatible with low-level speech technology components. An additional feature is a speech utterance detector which can determine the start and end point of a spoken utterance and can be used to help understand textual contents of the utterance.

Increasing the number of active wireless devices

To study the coexistence of licensed wireless systems in the same frequency bands covered by ultra-wideband (UWB) communication systems, a significant research effort has been launched. More specifically, the level of interference and corresponding degradation, reduction in the cell area and the increase in the outage probability were evaluated.

The recent developments in wireless technologies have increased the research interest in high data transfer rates and low-power systems for ad hoc networking. These networks allow the fast deployment of several applications, among which are local area networks (LANs) and personal area networks (PANs) covering offices and houses, as well as open wide areas.

Within the 'Ultra-wideband concepts for ad hoc networks' (UCAN) project, the possible use and benefits of a radio communication system based on an ultra-wideband physical layer (PHY) were investigated both theoretically and experimentally. UWB radio technology has attracted the interest of project partners due to its unexpected unlicensed operation and, importantly, the potential to provide high data transfer rates at relatively short ranges.

UWB technology is based on the radiation of waveforms formed by a sequence of very short pulses, where short refers to pulse duration of about a few hundreds of picoseconds. To achieve a system characterised by high-precision position localisation and target tracking, a set of 16 UWB transmitters was manufactured and evaluated at the Acorde S.A. laboratories in Spain.

Motivated by a real need for a thorough study of the potential interoperation and coexistence of UWB systems with other wireless systems, these pulse generators were designed to perform experiments. Including advanced communication modes such as multiple simultaneous connections inside the air channel, different aspects of a functioning UWB system were investigated in several scenarios of positioning and high transfer rate transmission.

The experimental results collected on UWB communication system performance served not only the UCAN project's internal research, but provided valuable insights to the wider telecommunications research community.

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Designing augmented human-plant interactions

A unique system that picks up the subtle cues from plants can help plant growers monitor their state of health and ultimately identify the optimal environmentally friendly growing conditions.

The complex interactive system of embedded sensors in and around plants growing in closed environments scans the entire crop canopy and measures the plant temperature along with the chlorophyll fluorescence. The data collected on the rate at which plants absorb energy, which reflect their current state of health, are interpreted into high-level context information and communicated through specially developed wireless transmitters.

This mixed society of plants and digital artefacts was regarded within the Plants project as a distributed system, which could globally manage its resources, functions and interactions with the environment. Plants were transformed into ePlants with enhanced computational and communication abilities,

which could be subsequently organised into groups in a virtual computing space. This hierarchical structure enabled the distribution of communication loads as well as its power and memory resources, but more importantly it facilitated distributed decision-making.

At the heart of the system's layered, modular architecture, designed within the Plants project, lies the management software. Both ePlantOS for the ePlants and eGadgetOS for the digital artefacts adhere to the same basic concepts, and communicate by using common protocols and message structures. The functionalities of this middleware, developed at the Computer Technology Institute in Greece, were further extended to include machine learning mechanisms and fulfil the evolving requirements of the mixed society.

An interface between minute biosensors and actuators is provided, while an enhanced, plant-specific ontology is maintained by the ePlantOS middleware. The input/output (I/O) unit and connectivity layers administer the communication intricacies as plants become more than an information source. Local and global decision-making in addition to distributed resource management can be supported as plants have the means to impact growing strategies in domestic environments, among other closed environments.

Moving this research effort one step further towards a more autonomous system with self-adaptation characteristics, the project partners will explore ways of incorporating artificial intelligence features into the system.

See also page 15 (offer 3903)

'What can I, Robot, do with that?'

A new approach to robotics and artificial intelligence (AI) could lead to a revolution in the field by shifting the focus from what a thing is to how it can be used.

Identifying what a robot is looking at is a key approach of AI and machine cognition. So far ambitious researchers have managed to teach a computer's vision system to recognise up to 100 objects. Granted, this is a huge achievement, yet far short of an *I, Robot* scenario.

But there is another radically different approach available that European researchers have applied to the study of robotics and AI. The 'Multisensory autonomous cognitive systems interacting with dynamic environments for perceiving and using affordances' (MACS) project does not attempt to get robots to perceive what something is, but how it can be used.

This is an application of the cognitive theory of 'affordances', developed by the American psychologist James J. Gibson between 1950 and 1979. He rejected behaviourism and proposed a theory of affordances, a term signifying the range of possible interactions between an individual and a particular object or environment. The theory focuses on what a thing or environment enables a user to do.

Computer vision might identify an object as a chair, but a system of affordances will instruct the robot that it can be used for sit-

ting. This system is key to the new approach. The system means that once an affordance-perceiving robot 'sees' a flat object of a certain height and rigidity, it knows that the object can be used for sitting. But it also means that an affordance-based robot will be able to determine that the flat object of a certain height and rigidity is too heavy to lift, and must be pushed, and that it can be used to hold a door open.

Ultimately, the aim of goal-oriented, affordance-based machine cognition is to enable a robot to use whatever it finds in its environment to complete a particular task. 'Affordance-based perception would look at whether something is graspable, or if there is an opening, rather than worrying about what an object is called,' explains Dr Erich Rome, coordinator of the MACS project.

Started in September 2004, the MACS project began with five scientific and technological goals. First, the researchers sought to create new software architecture to support affordance-based robot control. Second, they wanted to use affordances to direct a robot to complete a goal-directed task. Third, they wanted to establish methods for perceiving, learning and reasoning about affordances. Next, they wanted to create a system so the robot could acquire

knowledge of new affordances through experimentation or observation. Finally, the MACS team planned to demonstrate the entire system on a robotic platform called the Kurt3D.

The EU-funded project successfully created an integrated affordance-inspired robot control system. This included the implementation of a perception module, a behaviour system, an execution control module, planner, learning module and affordance representation repository. The proof-of-concept has been shown in various experiments with the simulator MACSim and in the real robot Kurt3D. 'We performed a physics-based simulation using a model of the robot,' says Dr Rome. We tested single components like perception and learning, and also the entire architecture in simulation. And then we tested the whole system in the robot.'

In that test, Kurt3D used affordance-based perception to identify what could be grasped, where there was free space, and what was traversable. The robot found an object, picked it up, and put it on a pressure-activated switch that controlled a door. Then, once the robot detected the passage, it opened and moved through the door.

The tests were a remarkable achievement. The robot essentially figured out how to manipulate its environment to achieve a real-world goal. It showed a capacity for improvisation. 'This is the very early stage

Motion planning for virtual entities

For computer-controlled entities to move around in virtual environments, motion-planning techniques originating from robotics have been adapted and effectively applied to plan their routes amidst obstacles and other moving entities.

Originating from studies in robotics, automated motion planning has recently found applications in computer games, as well as in maintenance planning and safety training in industrial computer-aided design (CAD) systems. In such virtual environment applications populated by numerous entities, it

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is essential that the simultaneous motion of coherent groups of moving entities rather than individuals is computed in real time.

For this purpose, researchers within the framework of the MOVIE project developed an innovative approach to motion planning for groups of virtual entities, modelled by a deformable shape. To avoid excessive motion computing time, individual entities are kept inside the deformable shape with the use of a newly proposed technique called 'group potential fields'. Combining the global motion of the group's shape with the internal motion could lead to the desirable coherent group motion.
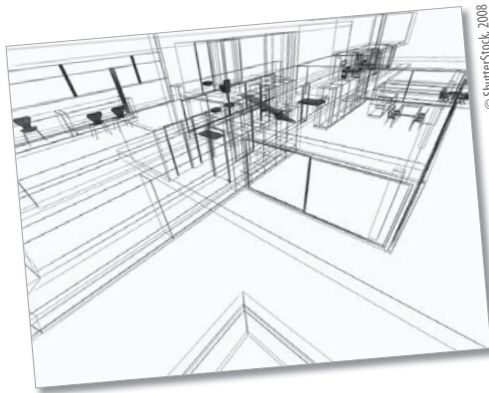
An extension of the widely used probabilistic roadmap (PRM) plan-

ning technique was used to construct a roadmap of all the possible motions of the deformable shape. Covering the entire configuration space of possible placements of the coherent group of virtual entities, the roadmap could then be queried to find the desired path. Moreover, in its simplest form, the motion-planning problem would require a collision-free path to be computed between the starting and final position.

The inclusion of alternative routes, taking known obstacles and objects (like building walls and doors) into account when creating the roadmap, permitted adaptation to dynamic changes in the complex virtual environment. Experiments revealed that after only limited pre-processing, these techniques and corresponding algorithms offer an efficient numerical solution to group motion queries almost in real time.

Smart personal computers for visually impaired users

User interfaces perceptible to the sense of touch facilitate access to the modern information technology world for visually impaired people. A European project has developed smart electrorheological (ER) fluid to provide the tactile display.

The absence of an interactive display has until now prevented the visually impaired from utilising many of the benefits of the information society. Accordingly, the Itacti project has developed a state-of-the-art interactive tactile interface peripheral in order to enable access to modern computer and Internet applications.

Smart materials produce an array of multiple actuators, a matrix of moving dots, therefore providing a very efficient computer control system. Along with an interface that displays tactile diagrams and multi-line Braille, full presentation of interactive documents can be achieved.

ER fluid is a smart material that has been used by the Itacti project partners for the production of the actuators. It has the ability to accurately change its flow properties from liquid to solid in a matter of milliseconds. But this ability was exhibited only when the ER fluid was subjected to electrical fields of the order of one megavolt per metre. Two parameters basically control the magnitude of the electric field — potential difference and the distance between the two electrodes. Large potential differences and small distances between the electrodes create large electric fields. Since megavolt potentials are prohibited, project partners have minimised the distance between the electrodes. With

electrode gaps of the order of 250 micrometres, potential differences of only 400 volts are required.

A new class of ER fluids was required that was capable of operating in such confined volumes. ER fluid with particles as large as 50 to 100 micrometres and dispersed in oil was proven unsuitable. Therefore, a new ER was developed with a particle size of 10 to 20 micrometres. Project partners are currently carrying out a patent search for this novel, environmentally clean and fully functional low-voltage ER fluid.

of this approach,' Dr Rome warns. 'So we are a long way from commercialisation. There are others working on it. But what is unique about the MACS project, is that we introduced direct support for the affordances concept in our architecture.'

And MACS has also made affordances a more mainstream concept in robotics, perception and cognition. Some of the partners

are involved in other projects, like ROSSI, which tracks the relation of language to actions (http://www.rossiproject.eu).

'The project helped generate a lot of interest in the concept and it is also now a very visible topic,' Dr Rome says. In all, MACS and its work have moved robotics into a new paradigm, teaching robots to identify what they can do.

The next step in robot development is child's play

Teaching robots to understand enough about the real world to allow them to act independently has proved to be much more difficult than first thought. The team behind the iCub robot believes it, like children, will learn best from its own experiences.

The technologies developed on the iCub platform, such as grasping, locomotion, interaction, and even language-action association, are of great relevance to further advances in the field of industrial service robotics.

The EU-funded RobotCub project, which designed the iCub, will send one each to six European research labs. Each of the labs proposed winning projects to help train the robots to learn about their surroundings — just as a child would.

The six projects include one from Imperial College London that will explore how 'mirror neurons' found in the human brain can be translated into a digital application. 'Mirror neurons', discovered in the early 1990s, trigger memories of previous experiences when humans are trying to understand the physical actions of others. A separate team at Universitat Pompeu Fabra in Barcelona will also work on iCub's 'cognitive architecture'.

At the same time, a team headquartered at Université Pierre et Marie Curie (UPCM) in Paris will explore the dynamics needed to achieve full body control for iCub. Meanwhile, researchers at Technische Universität München (TUM) will work on the development of iCub's manipulation skills. A project team from the University of Lyons will explore internal simulation techniques — something our brains do when planning actions or trying to understand the actions of others. Over in Turkey, a team based at the Middle East Technical University (METU) in Ankara will focus almost exclusively on language acquisition and the iCub's ability to link objects with verbal utterances. 'The six winners had to show they could really use and maintain the robot, and

secondly the project had to exploit the capabilities of the robot,' says Dr Giorgio Metta. 'Looking at the proposals from the winners, it was clear that if we gave them a robot we would get something in return.'

The iCub robots are about the size of three-year-old children, with highly dexterous hands and fully articulated heads and eyes. They have hearing and touch capabilities and are designed to be able to crawl on all fours and to sit up.

Humans develop their abilities to understand and interact with the world around them through their experiences. As small children, we learn by doing and we understand the actions of others by comparing their actions to our previous experience. The developers of iCub want to develop their robots' cognitive capabilities by mimicking that process. RobotCub researchers designed the iCub's hardware and software using a modular system. The design increases the efficiency of the robot, and also allows researchers to update individual components more easily. The modular design also allows large numbers of researchers to work independently on separate aspects of the robot.

iCub's software coding, along with technical drawings, are free to anyone who wishes to download and use them. 'We really like the idea of being open as it is a way to build a community of many people working towards a common objective,' says Dr Metta, one of the developers of iCub. 'We need a critical mass working on these types of problems. If you get 50 researchers, they can really layer knowledge and build a more complex system. Joining forces really makes economic sense for the European Commission that is funding these projects, and it makes scientific sense.'

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While the iCub's hardware and mechanical parts are not expected to change much over the next 18 months, researchers expect to develop the software further. To enable iCub to learn by doing, the RobotCub research team is trying to pre-fit it with certain innate skills.

These include the ability to track objects visually or by the sounds — with some element of prediction of where the tracked object will move to next. iCub should also be able to navigate based on landmarks and a sense of its own position.

But the first and key skill iCub needs for learning by doing is an ability to reach towards a fixed point. By October this year, the iCub developers plan to develop the robot so it is able to analyse the information it receives via its vision and feel 'senses'. The robot will then be able to use this information to perform at least some crude grasping behaviour — reaching outwards and closing its fingers around an object.

'Grasping is the first step in developing cognition as it is required to learn how to use tools and to understand that if you interact with an object it has consequences,' Dr Metta says. 'From there the robot can develop more complex behaviours as it learns that particular objects are best manipulated in certain ways.'

Once the assembly of the six robots for the research projects is completed, the developers plan to build more iCubs, creating between 15 and 20 in use around Europe.

The six project winners are:
- Imperial College London: Embodied cognition using internal simulation and a global workspace;
- Université Pierre et Marie Curie, Paris: Motor, affective and cognitive scaffolding for iCub;
- Centre National de la Recherche Scientifique (CNRS)/Université Lumiere Lyon 2: Development of shared intentions and cooperation in a humanoid robot via situated simulation models;
- Technische Universität München, Munich: iCub development of kids' manipulation skills;
- Universitat Pompeu Fabra, Barcelona: An integrated anthropomorphic neuromorphic cognitive architecture for the iCub;
- Middle East Technical University, Ankara: Emergence of communication in iCub through sensorimotor and social interaction.

Mini-machines for micro-manufacturing

Miniature mechanical components with micron to millimetre dimensions are used in the transducer, medical and aerospace industries, to name only a few. Tools and machinery to micro-deform miniature materials have been developed.

A number of mechanical parts inside our high-tech refrigerator are assembled from miniature components. From consumer white goods to aerospace industry, such miniature engineering materials are highly required.

With component thicknesses of the order of 20 microns and an overall bulk size of the order of a millimetre, most conventional deformation processes may result in serious and irreversible defects. Novel tools and machinery are required. Satisfying this demand has been the objective of the Machmini project.

Firstly, the plastic deformation characteristics of the miniature materials need to be defined. These characteristics have been utilised in pre-processing for developing an exact finite element software model. The computer model has substantially aided in product design, analysis, and development.

Subsequently, the Machmini machine, a new generation of forming machine, was constructed. The machine is a three-axis computer numerical control (CNC) machine capable of delivering the tool system to pre-specified locations. It carries an L-shaped frame, on which a variety of tools and dividing heads can be mounted. The geometry facilitates component manipulation on both the x- and y-plane.

Standard numerical control codes like G-code may be used to program the Machmini machine. A key innovation in the design of the Machmini machine is the incorporation of a Z1-signal that
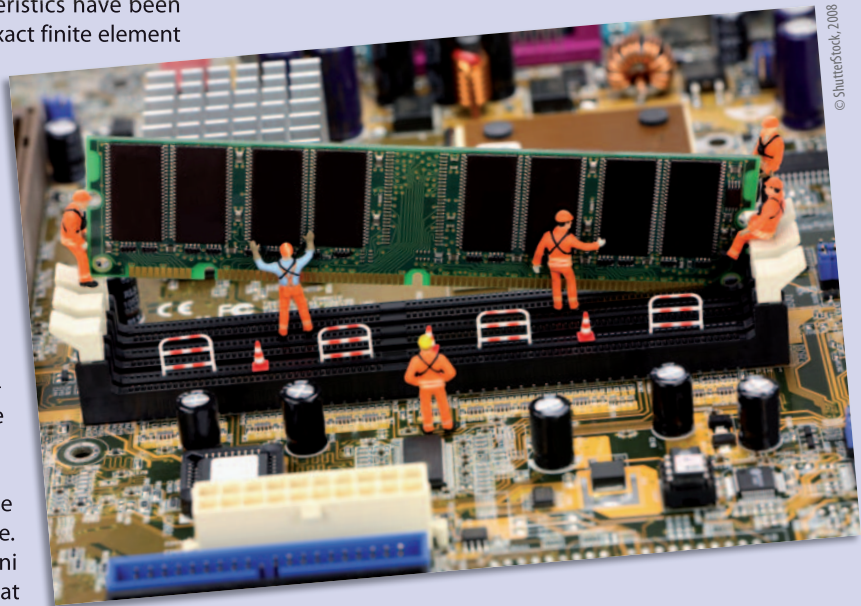
allows the supply of conditioned signals to the tool system. The constructed three-dimensional capability reveals the potential of forming complex component geometries.

A prototype Machmini machine is available for testing while other samples have already been delivered to major industries for extensive performance trials.

Minimising power consumption in finish grinding

The introduction of a new sensing technology for monitoring acoustic emissions in grinding operations is expected to lead to significant reductions in power consumption.

From automotive parts to bearings, grinding constitutes one of the most important production processes of modern industry. Yet, this critical machining operation in precision manufacturing processes is still considered as extremely demanding in energy resources. Motivated by this, the ENGY project aimed at designing and implementing low-energy and eco-efficient grinding technologies.

In order to improve the energy efficiency of grinding, the entire grinding system including machine, tool, process control and parameters was investigated. One of the major causes of the large amounts of electrical energy consumption was attributed to stationary operated subsystems of the machine tool. In spite of their actual process state, these systems account for significant energy consumption irrespective of any modifications in grinding parameters. Hence, energy savings in grinding would require shorter process times.

Spark-out operations are considered critical for the workpiece's quality in terms of roundness and surface roughness properties. Putting spark-out operations under the microscope,

researchers focused on the spark-out time without compromising the piece's quality. More specifically, the key issue was to specify the ideal spark-out time required to process the worst possible input.

A new sensing device was developed that would allow adaptive control of spark-out time on the basis of identified quality parameters such as roundness error. The system relies on signals of acoustic emissions in order to record information on the actual part geometry within the process. For further information, please visit the project site: http://www.lms.mech.upatras.gr/engy

See also page 47 (offer 4007)

Microwave processing of composite materials

High-frequency microwave processing, as a relatively new technology, can provide a promising alternative for enhancing material properties as well as economic advantages through energy savings and accelerated product development.

State-of-the-art technologies for producing large thermoplastic composite components show serious disadvantages. Mould tools need to be heated up in a short time, and when processing temperature has been reached, they need to be cooled abruptly, requiring an expensive energy balance. The ultimate aim of the Amiterm project was to overcome both the economic and environmental issues that have arisen though an improved energy balance.

Correction and optimisation of the energy balance in the production of large thermoplastic composite components without the thermal shock on which current processes are based will allow high-speed production. During the proposed JETex process, a low-viscosity pre-polymer is injected into a non-metallic mould carrying two- or three-dimensional textile-reinforcing structures, which can be woven or knitted. Electromagnetic heating is then used to initiate polymerisation and form the thermoplastic component.

This application of controlled high-frequency microwave heating enables a higher degree of conversion of monomers into polymer chains, thereby enhancing the physical characteristics of the final thermoplastic component. More importantly, microwave heating has significant advantages over conventional heating techniques due to the ability to heat specimens directly through specific interaction of electromagnetic radiation with its material. Research work conducted at the laboratories of Kunststofftechnik Beiner in Germany was successful in identifying the most appropriate microwave response of thermoplastics and, moreover, in shortening their processing times.

Upgrading high-energy, ultra-fast experiments

New technology for direct amplification of high-power visible femtosecond laser pulses has been developed.

Modern physics experiments investigating new domains such as particle acceleration or laser-assisted nuclear physics rely heavily on ultra-high-intensity pulses. Despite the recent advances in laser technology, there are still imperfections in the pulse temporal profile coming from high-level amplified spontaneous emission pedestals and pre-pulses.

Addressing this need, the SHARP project focused on the development of new methods and tools in order to achieve the optimal temporal contrast for laser-material interaction. In this context, the associated non-linear effects can result in significant reduction of the amplified spontaneous emission level in relation to the ultra-fast (femtosecond) pulse.

One of the key project results involved direct amplification of high-power visible femtosecond laser pulses with the aid of a xenon fluoride (XeF) (C-A) laser. The compact photolytic device displays a low non-linear index of refraction that allows direct amplification, without pulse stretching. Moreover, it can also provide very high-energy, ultra-fast laser pulses in the blue-green region.

Due to its low small signal gain and a relatively long radiation lifetime (100 ns), the photolytic XeF gas medium offers a low level of amplified spontaneous emission. In addition to this, the medium shows a broad amplification bandwidth along with a rather high saturation fluence.

These capabilities make the device ideal for use in the development of ultra-high power laser systems (up to petawatt levels). It has been designed with the least possible complexity in order to allow cost savings in production. On the other hand, its design limits the occurrence of pre-pulses offering considerable minimisation of energy losses.

Therefore, the device is very suitable for obtaining high-contrast, high-power femtosecond pulses and can be used in multi-terawatt and even petawatt ultra-fast laboratory facilities. Examples of high-field physics experiments involve time-resolved dense plasma diagnostics, generation of laser plasma and x-ray sources, ignition of photonuclear reactions, particle acceleration or exploration of the relativistic regime of radiation-matter interaction.

Monitoring plasma thermal spraying

Plasma thermally sprayed coatings are used for many applications, in mining, combustion engines, infrastructure and marine environments, to name a few. A novel acousto-optic spectrometer has been developed to monitor the plasma properties involved.

Thermal spraying, as its name suggests, is the delivery of hot, fast, plastic particles onto a surface. The minute droplets — now down to nano-size — are heated by and transported within a flame, created in most cases by a plasma gun. Thermal spraying coatings are used to cover friction joints that are subjected to high contact loads and high temperatures. The deposition of nanophased powder material by high-energy fluxes and the consequent novel tribological properties the target surfaces acquire have been extensively researched by the TRIBO project.

Monitoring the plasma parameters during thermal spraying is of great importance. A TRIBO project partner, Institut für Umweltanalysen (IFU) in Germany, has developed an acousto-optic spectrometer (AOS) that monitors the optical emission of thermal spraying processes in real time. The acousto-optic interaction occurs inside an anisotropic silica (SiO_2) crystal and, in contrast to conventional spectrometers, no diffraction gratings or prisms are required. Moreover, since the AOS spectrometer is based on acousto-optic phenomena, it does not possess any moving parts.

The modes of operation supported for process control are the spectral scanning mode (called spectrum mode) and the chronogram/time tracking mode. The spectrum mode scans a wavelength range with steps of 5 milliseconds each and provides accurate intensity information. The chronogram mode randomly selects a wavelength and, with the aid of control software, can be used to monitor or to regulate thermal spraying processes.

Eco-friendly methods for cleaning industrial equipment

A competitive environmentally compatible cleaning technique based on supercritical carbon dioxide has been developed for cleaning semiconductor and electronic components.

Workers in the semiconductor and electronics industry are exposed to solvents which can pose a serious health concern. This is because solvents commonly used as cleaning materials for electronic components include deionised water, chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). These are not only costly, but can also have adverse effects on the environment and on humans if volatile in nature.

In answer to this, the Eco2Clean project has created an eco-friendly cleaning process to help reduce and possibly eliminate the use of harmful solvents in cleaning. A novel supercritical carbon dioxide was produced under controlled conditions. It is non-toxic, non-flammable and also non-ozone-depleting. Moreover, its potential for contributing to global warming is very low.

The commercial implementation of this process was essentially based on the industrial application of cleaning equipment. The process is capable of accommodating a broad range of electronic and semiconductor substrates for metallic, ionic and particulate removal. Ultimately, the implementation of this eco-friendly cleaning process can contribute to better working conditions and safety at the workplace.

Computational fluid dynamics serve fashion and art

The deposition of thousands of individual fibres (flock) on a vast variety of articles has been used for hundreds of years in fashion and art. From research into the spray deposition of paints, a novel coating technology for flocking has been developed.

Flocking has an unexpected variety of applications in a number of industrial processes. Your car dashboard is most probably flocked with some material so that sunlight will not be reflected on the windscreen. At some time, we all have worn a flocked textile, in the form of a simple T-shirt or a precious fashion article.

But flocking means depositing millions of fibres on an article, and that raises issues of health and safety hazards caused by flock fibre dispersion in the air. The 'Fur- and flocking-like innovative coating' (FFLIC) project addressed such issues and developed innovative coating technologies, especially for the texture industry. These produce similar flocking appearance at much lower cost and at the same time pre-empt all environmental hazards.

Central to the development of this novel coating technique is the ability to predict spray deposition of paints. Sophisticated and accurate in their predictions, numerical methods based on fluid dynamics for simulating paint deposition from paint guns were a major step forward for project partners. The predictive method combines a model for the impact of droplets onto a surface with a Lagrangian tracking of the spray. Knowledge of the distribution of the sprayed paint results in a more uniform deposition and therefore a higher-quality coating.

The method, when applied to standard paint guns, provides accurate predictions for the thickness of the deposited paint on a variety of different geometries. The accuracy of the results has been checked against already existing experimental data for the flow field of a spray gun. However, when the method uses fluid dynamics algorithms, it extrapolates and creates conditions for which experimental data are not available. The model for paint deposition can also be used for the development of new spray guns.

Project partners offer their acquired expertise for consultancy in the field of paint deposition and are willing to contribute it for innovative collaborative research in both industrial companies and academic institutions.

The AOS spectrometer has been thoroughly tested and the developer is currently seeking a joint venture agreement, manufacturing agreement or a private-public partnership to proceed with its industrial production. Furthermore, the expertise acquired is available for consultancy and information exchange.

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Reaction bonding for silicon carbide

A reaction bonding process for silicon carbide (SiC) has been developed, enabling an improvement in purity as well as applicability.

SiC is an extremely hard, blue-black crystalline compound used as an abrasive and as a heat-refractory material. SiC is a main semiconductor material which can assist the development of high-power and high-temperature electronic devices and industrial high-temperature sensors.

SiC crystals consist of two main polytypes. Only the hexagonal SiC is currently available commercially. The physical and electronic properties of cubic SiC are not very well known, yet it is likely that they could be very advantageous, presenting more potential and fewer limitations than hexagonal SiC. In light of this, the Solsic project has sought to develop bulk cubic SiC crystals to advance cubic SiC properties.

In addition to this, the purity of the reaction bonding technique was improved. This was necessary since the traditional processing technique used relied on sintering aids. These inevitably introduce impurities that are needed in assisting the material to react and form a dense body. Sintering aids can therefore be problematic, causing contamination that is harmful to the application. The new technique should be useful for aerospace, automotive and electronic component manufacturers.

Increasing comfort on board

The Compass project aimed to improve the passenger comfort in high-tech ship transportation by advancing motion sickness prediction models and realistic standards.

During the past decades, shipbuilding has advanced considerably, making sea travel faster, safer and more comfortable. Despite the improvements and the vessels withstanding severe weather conditions, motion sickness standards have still not been updated to include recent developments.

Motivated by this, the Compass project focused on an innovative prediction model for motion sickness and the development of standards for passenger comfort that are closer to the new reality. The model and the standards are expected not only to improve the safety of passenger and crew, but also the reliability and efficiency in the operability of new vessels.

Until recently, most lab and in-field studies were based on a technique that allows the prediction of discomfort caused by multi-axis vibration at a frequency range between 1 to 100 Hz. Little information was provided for discomfort at lower frequencies (less than 0.5 Hz), while limited data were available for discomfort caused by the combined roll and lateral (or pitch and fore-aft) oscillation.

Aiming to extend current knowledge on the interrelation between low-frequency motions, discomfort and impact of activities of passengers and crew, several experimental studies were conducted. This research focused on the frequency-dependence of motion sickness caused by roll (at 0.025 to 0.4 Hz) and horizontal oscillation (at 0.0315 to 0.20 Hz). Re-interpretation of these data also allowed researchers to estimate frequency weightings for prediction of the impact of horizontal and rotational motions.

As low-frequency translational and rotational motions are normally found in fast vessels, the valuable data could also contribute to the prediction of discomfort in these new-generation ships. This information could also improve the design of new ships and prove useful in the European shipbuilding industry to attract new operators. For more information, please visit the project website: http://www.compass.cetena.it

Effective high-temperature circuit testing

Modern semi-conducting chips used in the automotive, aerospace and oil extraction industries must operate reliably in high-temperature environments. An effective test strategy has been developed to detect circuit failures.

In many industrial applications, safety and efficiency electronic systems are made up from miniaturised integrated logic and memory circuits. To ensure safety and reliability, these circuits must operate properly even when exposed to temperatures as high as 200 °C. In the automotive, aerospace, avionics, ship and oil extraction industries, working environments with even higher temperatures exist and circuit failure modes have to be seriously considered. The ATHIS project has developed highly efficient testing strategies capable of identifying defective circuits.

Very large-scale integrated (VLSI) circuits are being continuously minimised. Consequently, thin-film conductors and interconnects are subject to higher current densities.

In combination with a high-temperature environment, the most important failure mode that manifests itself is electromigration. Momentum transfer between conducting electrons and the ions that make up the lattice of the substrate material simply result in the actual transport of material and the inevitable breakdown of the circuit involved.

Electromigration is not the only high-temperature failure mode. Time-dependent dielectric breakdown (TDDB) and hot-electron effects must also be considered. Highly energetic electrons, hot electrons, capable of tunnelling through the thin oxide gate, show up as gate current, and cause circuit failure. TDDB is one of the most heavily researched failure mechanisms in the semiconductor reliability community. Since the 1960s, researchers have struggled to understand the nature of how an oxide degrades over time. Nevertheless, both physical phenomena, TDDB and hot electron effects, depend very little on temperature, and the main failure mechanism remains electromigration.

Since electromigration manifests itself as either a short or an open circuit, current and voltage test methods suffice for failure detection. Project partners have developed sophisticated fault models to be used by design automation tools for the creation of accurate test patterns. The ATHIS project has therefore considerably contributed to enhancing high-temperature circuit reliability.

Road safety: the uncrashable car?

The largest road safety research project ever launched in Europe will usher in a series of powerful road safety systems for European cars. But, in the long term, its basic, experimental research could lead to a car that is virtually uncrashable.

A truck exits suddenly from a side road, directly into your lane only dozens of metres ahead. Suddenly, your car issues a warning, starts applying the brakes and attempts to take evasive action. Realising impact is unavoidable, in-car safety systems pre-tension the safety belts and arm the airbag, timing its release to the second before impact.

Such is the promise of the uncrashable car, coming to a dealer near you in the perhaps not-too-distant future. The system is part of the basic research undertaken by the largest research initiative into road safety ever undertaken in Europe.

The Prevent project has a budget of over EUR 50 million and 56 partners pursuing a broad, but highly complementary programme of research. A dozen subprojects focus on specific road safety issues, but all support and feed into each other in some way.

Prevent is studying relatively cheap, even simple, technologies — such as parking sensors and existing satellite navigation — that can be retooled to enhance driver safety. But as part of its broad and deep approach to car safety, it is also diving into more experimental and medium- to long-term systems, innovations that could appear in 5 to 10 years.

The uncrashable car is a theoretical construct that concerned a handful of Prevent's subprojects. But it could become far more of a reality than anyone expected. Of course, it is impossible to stop all car collisions, but the technology could be pushed to make it increasingly unlikely and mitigate crashes when they do occur.

For example, Prevent subproject Willwarn uses wireless communication with other vehicles to alert the driver about potentially dangerous situations ahead, while MAPS&ADAS reads sat-nav maps to track approaching hazards, like bends, dips or intersections. Saspence looks at safe driving distances and speed, while Lateralsafe finally brings active sensing to the blind spot.

All have their role in the uncrashable car, as do many others within the broader project. But two subprojects, Apalaci and Compose, take this a step further, actively tracking the speed and trajectories of surrounding vehicles and other road users in real time. If one vehicle suddenly stops or a pedestrian suddenly steps onto the road, they swing into action to rapidly calculate the implications.

Apalaci is an advanced pre-crash mitigation system built around the registration of other motorists and cyclists. In the Apalaci system, sensors monitor the street or road immediately around the vehicle and collect as much information about a collision as possible, before it even starts to take place.

The system uses these data to decide on the ideal safety reaction strategy. Examples include controlled braking manoeuvres, controlled activation of the occupant restraint systems or pre-arming airbag systems. The car can react far faster than the driver, cutting speed by crucial amounts to ensure unavoidable accidents are less severe.

Apalaci also developed a so-called 'start inhibit system' for trucks. It surveys the blind spot immediately in front of a truck

and protects pedestrians or cyclists by preventing dangerous manoeuvres.

Apalaci was tested in a series of vehicles like the Fiat Stilo, the Volvo FH12 truck, the Alfa Romeo 156 and the Mercedes E350. It used laser sensors, radar, software decision assistance and a variety of other technologies to achieve the goal.

Compose, on the other hand, aims more specifically to keep others, as well as its driver, safe. It can apply the brakes if a pedestrian steps onto the road, or extend the bumper, and raise the bonnet to enhance occupant protection.

Tiny differences have a huge impact on car safety. Dropping speed by 1 km/h can reduce accidents with injury by 3 %, while braking fractions of a second sooner is enough to reduce the damage caused dramatically.

The systems were tested in the BMW 545i and the Volvo FH12 truck, and they do appreciably enhance safety. But, for all their potential, these systems remain, for now, the preserve of the future.

'The teams developed sophisticated algorithms to track all these elements in the landscape,' explains Matthias Schulze, coordinator of the EU-funded Prevent project and Senior Manager for ITS & Services at Daimler AG. 'But they require enormous computer power to keep track of all the various elements, so this work is aimed at basic research, establishing how it could be done. It will be a while before in-car computers are sophisticated enough to use these systems.'

Nonetheless, they do provide tools that automakers can use to mitigate the potential for accidents, and they provide a clear research roadmap for the uncrashable car of the future.

Studying self-assembled semiconductor nanostructures

The Nanomat project has shed more light in the science and technology of quantum dots and their exploitation in optical data storage and nano-electronics.

In the magnificent microworld of semiconductors, quantum dots are composed of excitons — bound states of pairs of an electron and an imaginary particle — confined in all three dimensions. Due to their properties, which are similar to those of an atom, quantum dots have received much attention recently for studying the physics of confined carriers and many-body effects. Such studies may lead to new innovations in quantum computing, optics and optoelectronic devices.

Urged by this, the Nanomat project focused on the spontaneous formation of nanometre-sized droplets of semiconductor material on a lattice-mismatched substrate. Part of the project work involved the determination of the confinement and exciton properties of quantum dots and other self-assembled nanostructured materials (SANMs). For this purpose, a set of appropriate experimental and theoretical tools and techniques were generated. The adoption of the new methodology can provide a better insight into the electronic and optoelectronic properties of all stacked semiconductor nanostructures.

End-users of the new methods and tools include all those interested in the research and development of semiconductor nanostructure (devices), belonging either to the wider scientific community or industry. A certain limitation with the exploitation of the new methodology to its full potential is that users need to have a deep knowledge or possess necessary infrastructure. Other than that, the methodology can find several applications. For more information on the project, please visit: http://www.fys.kuleuven.ac.be/vsm/nanomat

Nano-probing liquids

Up until now atomic force microscopy has been used to image and manipulate atoms and structures solely on solid surfaces. Innovative probes capable of electrical measurements in liquid media have been designed and fabricated.

The atomic force microscope is currently the most valuable tool for imaging, measuring and manipulating matter. Its resolution is a fraction of a nanometre and it essentially measures topography with the aid of a force probe. The probe is attached to a cantilever of micro-dimensions and the radius of its curvature is basically the only factor that limits the microscope's resolution. The Spot-nosed project has fabricated such probes to be used for electrical measurements in liquid media.

This novel type of atomic force microscope consists of a cantilever attached to the plane surface of a silicon chip with a tip, the probe, in the shape of bird's beak protruding at its end. The tip is made out of polycrystalline silicon while silicon nitride is used for the cantilever. Tip and cantilever are coated with a gold conducting layer. A metal is required to facilitate electrical measurements and specifically gold for biocompatibility reasons.

Atomic force microscopes do not 'see' in the sense that they do not detect light. When subjected to the intermolecular interaction forces in the substance that is being probed, the cantilever vibrates, simply following Hooke's law. This deflection is the signal that is subsequently transformed into an image of the surface. Therefore spring constants characterise the cantilevers. Since biological liquid samples are targeted, project partners have fabricated rectangular and V-shaped cantilevers, with spring constants ranging from 0.01 to 1 N/m.

The experimental laboratory prototypes of atomic force microscope probes developed have been extensively and successfully tested.

New formula magnesium coatings

Magnesium is increasingly used to manufacture strong yet lightweight components to increase the eco-efficiency of cars, planes and spacecraft. Researchers therefore continue to investigate the application of innovative resistant coatings to prevent the inherent corrosion and abrasion of magnesium alloys.

Magnesium as an industrial metal has huge potential as it is a low-density, high-strength material which is easy to machine. As such, it is used in the automotive and aerospace industries, where speed and strength need to be combined. One of the disadvantages of magnesium is that it is relatively reactive and therefore prone to corrosion. Its main industrial competitor, aluminium, is less reactive. As a result, manufacturers and researchers have endeavoured to develop coatings to protect magnesium alloys from the ravages of corrosion.

The Nanomag project aimed to produce new corrosion- and abrasion-resistant coatings to protect magnesium parts. Traditional methods, although economical, have the inherent disadvantage of producing toxic pollutants such as chromates. The objectives also embraced the aim of producing protective layers that were eco-friendly and economical.

Partners from the corporate research centre at EADS Deutschland GmbH in Germany worked on a range of coatings for different alloys. The technique of low-pressure plasma-enhanced chemical vapour deposition (PE-CVD) was applied to cast alloys, in particular to the magnesium alloy AZ 31. The coatings used had ceramic properties and were based on a variety of compounds, for example, silica or SiO_2. This coating was found to be especially useful for surfaces with low roughness that have been machined and polished. Successful performance of the coating depended on alloy type and its surface topography.

Other techniques put under trial were application by plasma discharge in a liquid elec-

Advanced science for improved ceramics

It is the glaze that seals the porous and humble clay that essentially transforms an otherwise worthless piece of ceramic into fine and valuable porcelain. With hot-stage microscopy and gradient testing, critical and practical parameters of ceramic glazes are defined.

A ceramic glaze is a thin, shiny and transparent coating that covers clay products like pottery, porcelain or bricks. It is a vitreous substance, a glassy material that when baked seals the porous underlying clay and produces the familiar hard surface.

Due mainly to its glassy amorphous state, it is difficult to define critical points and consequently characterise ceramic glazes. Moreover, as the glaze temperature rises and reaches the sealing temperature, concurrent bubble formation most likely occurs. Enclosure of bubbles in the glaze significantly deteriorates its properties.

With the aid of elaborate scientific methods, the Bucoglacer project has developed innovative processes to control bubble formation in glazes of ceramic products. Using gradient testing, the sealing temperature can be specified. Complementary to gradient testing, hot-stage microscopy was employed for observation of the specimen with varied temperatures.

Hot-stage microscopy produces a state-of-the-art image analysis of the glaze sample as a function of temperature. With the aid of image analysis techniques, characteristic points in the melting behaviour of the glaze

can be defined. These characteristics contribute to the calculation of glaze viscosity as a function of temperature from known formulae.

Even though knowledge of viscosity and sealing temperature suffices to completely determine glaze behaviour, project partners also used the method of heating dish microscopy. It proved to be an effective and significant tool for assisting with the ultimate elimination of bubble development in the glaze. The method also provides the basis for the development of new measurement standards that could be incorporated in future European ceramics standardisation.

Spinel for coating is like the ruby of jewels

Widespread usage of light magnesium alloys is constrained due to their predisposition to corrosion and abrasion. An environmentally friendly coating process consisting mainly of spinel has enabled a multitude of new functional applications.

Industrial production of lighter yet durable vehicles would immediately result in reduced fuel consumption with obvious economic and environmental benefits. Magnesium, due to its low density, tends to replace steel and aluminium in many industrial applications, in the automotive industry for instance, and is nowadays widely used.

However, an important drawback to its usage is that it is prone to corrosion and abrasion. Previously, several coating processes had been developed, but they were all environmentally hazardous and economically unfavourable.

An innovative coating process has been developed by the Nanomag project. This process is not only highly efficient, but also clean and economic. The treatment called keronite is an electrolytic oxidation coating for magnesium. With the aid of a plasma discharge around a component immersed in an electrolyte, a hard ceramic film of uniform thickness of 10 to 50 microns is deposited on the component.

The ceramic is a complex oxide, a magnesium aluminium oxide known as spinel. It is a hard mineral well known to jewellers due to its ruby-like colour. With spinel as its

main constituent, the resulting coating layer provides high hardness and wear resistance. As for corrosion resistance, a keronite-coated magnesium alloy survived 1 000 hours in a salt spray environment without exhibiting any traceable evidence of corrosion. Keronite also provides protection from galvanic corrosion since it substantially reduces the density of the electrolytic current.

Finally, the keronite coating can be used in conjunction with other coating processes when, as in the space industry, magnesium alloys are subjected to extreme conditions. Keronite with its porous upper surface acts as a substrate for the second coating.

trolyte, plasma-assisted physical vapour deposition (PAPVD) and the thermal spray process. The thermal spray process is a technology that can be used to solve challenging surface engineering and material problems. The thermal spray technique produces a coating by a process in which molten or semi-molten particles are applied by impact onto a substrate.

Ironing out the disadvantages of magnesium may mean that manufacturers will be more inclined to include it in processes when a light metal is required. Magnesium has many eco-friendly properties. For example, magnesium requires lower energy input for recycling. Wider use of magnesium parts in

the automotive and aerospace industries will also be likely to lead to lower fuel consumption with consequent lower CO_2 emissions.

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INDUSTRIAL TECHNOLOGIES

Improving quality in consumer products

Based on advanced sensor technology, new techniques for in situ *process quality improvement were demonstrated offering high-volume, high-yield and continuous production benefits.*

The Assyst project aimed to improve product quality and process control in manufacturing activities using advanced laser spectroscopy techniques. On the basis of tuneable diode near-infrared lasers, project partners developed novel optical sensors whose monitoring potential was extensively explored.

Near-infrared diode laser spectroscopy (NIR-DLS) shows several advantages, such as high sensitivity and spatial resolution as well as capabilities for easy integration. These features make it highly suitable for non-invasive, *in situ* applications and unique in monitoring reactive or corrosive gases.

Within the project scope, five sensor applications were demonstrated, one of which was an *in situ* process quality improvement in a factory of consumer products. Apart from the dedicated NIR-DLS unit, the developed lab-scale equipment involved a multi-pass optical cell and a set-up to test the instrument's performance under varied pressure and concentration conditions.

The key aim was to explore the feasibility of non-destructive measurement of gas phase compositions at the parts-per-million (ppm) level inside glass enclosures. The feasibility of the developed lab equipment was successfully demonstrated. Furthermore, studies on the performance and process details were completed in order to improve the efficiency and reliability of the demonstrator.

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New-age optical sensors for breath analysis

Optical sensors are an extremely valuable tool for monitoring, and consequently controlling, a large number of industrial processes. The near-infrared laser diode (NIRLD) spectrometer is the prominent candidate for leading the next generation of sensors.

It is very difficult to probe inside a sealed chamber kept at high temperature and controlled pressure, such as a chemical vapour deposition (CVD) reactor filled with hazardous gases like arsine. But diode laser spectroscopy in the near-infrared can successfully and efficiently monitor the gas chemical reactions that occur while a thin film is deposited on a solid surface inside the reactor. NIRLD spectroscopy is not limited to industrial manufacturing processes. Recently, it has been successfully applied in the telecommunications industry, and now a multitude of potential new applications is envisaged.

The Assyst project has greatly assisted in manufacturing a miniature of a tunable diode laser (TDL) instrument. This novel next-generation optical sensor uses a distributed feedback (DFB) laser. It can be produced at a much lower cost without compromising performance. An optical spectrometer of reduced dimensions can be used extensively in applications where non-invasive, *in situ* process control is required.

Project partners have also developed new laser designs for cavity-enhanced spectroscopy. Diode laser-based sensors are compact, have low power requirements and high sensitivity and are capable of detecting parts per billion (ppb) and even lower parts per trillion (ppt) concentrations of gases. With a small volume cavity and a long wavelength DFB laser or an infrared quantum cascade laser, detection of NO_2 and CO_2 isotopes was demonstrated.

A portable instrument with such high sensitivity in detecting gas compounds has already found an important innovative application. A laboratory prototype has been developed for use as a human breath analyser. The prototype measures, in CO_2 for example, the ratios of carbon 13 to carbon 12 in human breath. Such measurements are commonly used during exercises to evaluate the oxidation rate of exogenous carbohydrates enriched in carbon 13. More importantly, these measurements trace the metabolism of isotopically labelled drugs.

Introducing noiseless tool design

A new method for identifying the correlation between noise and wear in punching tools is expected to aid significantly in the reduction of noise originating from industrial structures.

One of the environmental hazards of the modern mechanical machinery industry stems from the high levels of noise it generates. Particularly, machine tools such as punching machines produce excessive noise leading to potential physical and physiological harm to workers in the long term.

Although provision was made to reduce noise levels within closed industrial surroundings, little effort was made to consider this aspect in the design process of machines. Addressing this issue, the Noiseless project focused on designing more 'quiet' machine tools by taking effective noise control measures while reducing wear and improving tool life.

Part of the project work involved the development of a new method that allows identification of tool wear and its correlation with noise. The method can be employed in punching tools and offers wear analysis with the aid of optical and con-focal techniques. The derived tool profiles displayed different levels of wear, which can then undergo further inter-comparison.

The method can find useful applications in tool manufacture for analysis of correlation between noise and wear. Its adoption can improve the efficiency of design procedures and reduce excessive experimentation, which is costly. Moreover, through optimised design, the tool life can be extended, while noise generation and transmission to the environment are considerably limited.