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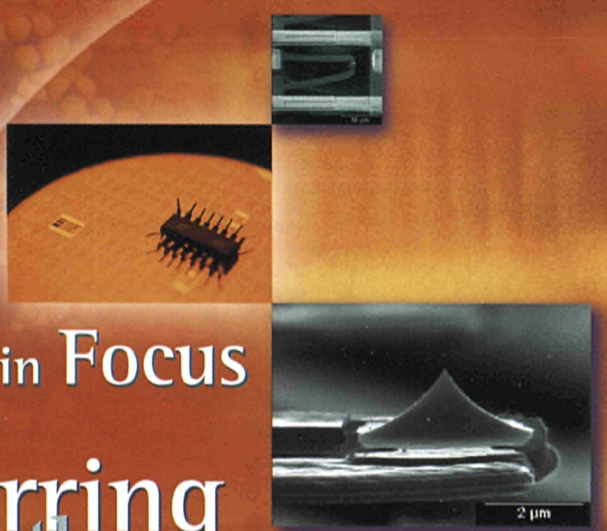
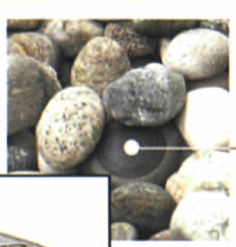


in Focus

Blurring the Boundaries of Nanotechnology



Demining

A technological imperative

Clean car

Five hundred kilometres with zero emissions

Supplement: The key-actions of the Fifth Framework Programme

RTD *info* 21

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In a supplement: the key-actions of the Fifth Framework Programme

Mrs Edith CRESSON, Commissioner for research, innovation, education, training and youth.
Directorate General XII - Science, Research and Development

RTD Info is a magazine on research and technological development supported by the European Union. It covers general aspects of Community research such as project results and research policy, as well as practical information including dates of calls for proposals, events, conferences, publications, and so on. RTD Info is aimed not only at current and potential participants in Community research programmes, but also at a wider public of industrialists, decision-makers, students, and others who are interested in developments in European research. Published quarterly, RTD Info is available in English, French and German. Subscription is free. To subscribe, fill in the form below.

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A turning point for Community research

After a process lasting more than two years, on 22 December the Council of European Research Ministers adopted the Fifth Framework Programme, in co-decision with the Parliament. Its budget of 14.96 billion euros represents an increase of around 4.6% on the previous programme. In the present budgetary context, this clearly reflects the interest of Member States in European research.

I should like to stress that this Fifth Framework Programme is more than just the continuation of previous programmes. It represents a significant change of emphasis. Research focused on performance for its own sake has given way to research concentrating on current socio-economic problems. Also, the available resources have been concentrated on carefully targeted priorities, thereby avoiding spreading finances too thinly, which has too often limited the impact of our efforts.

On a number of occasions, I have drawn attention to the drawbacks of the present procedure, in particular those stemming from the requirement for unanimous adoption of framework programmes. This rule means that the Union's research priorities are in danger of reflecting national and sectoral priorities rather than a genuine common research policy. Fortunately, the Treaty of Amsterdam will allow future programmes to be adopted by a qualified majority, which should make it possible to bring changes to the form as well as the content.

The new framework programme will be officially launched at the Essen Conference on 25 and 26 February (see page 14). It will provide a valuable instrument for strategic planning over throughout the next five years for Europe's researchers and industry. This is evidently a major event for the various partners in research and innovation. But its benefits and impact will also extend far beyond these specialist circles. It will allow European society as a whole to draw increased benefit from the technological progress which will mark our entry to the 21st century, especially in terms of creating the jobs we need so much.

This is why we wanted to provide as much information as possible as the programme gets underway. Hence the Essen Conference, the publication of this special issue presenting all the "key actions" of the Fifth Framework Programme, and the development of information on Community research on our world wide web sites.

Providing information is all the more essential as this Fifth Framework Programme is designed to be much more accessible to small and medium-sized enterprises, which have found it difficult to participate in our programmes in the past. Because of this, we have included special measures to help them take part, thereby stimulating their ability to innovate and to create new jobs, of which they are Europe's principal source.

While more investment in research is needed in order to win new markets, it is also necessary to make every effort to give innovation a more favourable environment than is currently the case.

This is exactly what this framework programme provides. It is not only designed to support research and technological development, it also has the tools to help promote technology transfer, easier access to venture capital, increased protection of intellectual property rights and the development of human resources.

The Fifth Framework Programme offers a new order for Community research. Its success now depends on the effective mobilisation of industry and researchers in pursuit of its principal objectives. It is by combining the creativity of its companies with the excellence of its scientific institutes that Europe will create the wealth it needs to create a balanced society of fulfilled individuals.

Edith Cresson

Edith Cresson
Member of the Commission responsible for research, innovation, education, training and youth.

Blurring the Boundaries at the Atomic Scale

The microelectronics industry's race for miniaturisation is fast approaching the realm of nanotechnology. A new, more multidisciplinary paradigm is required, with major implications for fields as diverse as microelectronics, quantum physics and biology.

Just what is nanotechnology? Pick up a paperback at the next bookshop you visit and you'll read about tiny machines patrolling your blood vessels, constantly repairing the slings and arrows of outrageous fortune. Other books will warn of the 'Star Trek scenario', where rampaging nanomachines turn the planet into grey sludge, or summon up a vision of perfectly built structures - vehicles, or perhaps even spacecraft - emerging like butterflies from a soup of tiny assembling machines, programmed using the industrial equivalent of DNA. But what do the scientists think?

"Nanotechnology has often been defined as the science of fabricating, characterising and using structures from the atomic scale up to around 100 nanometres," says Dr Marc Van Rossum, head of Advanced Materials and Nanoelectronics research at IMEC, the Belgian microelectronics R&D institute. "But this definition is simply not much use because it embraces so many fields - from electronics and physics, through biology and chemistry and on to mechanical engineering. And who set this 100 nanometre limit?"

What's in a Name?

Dr Rossum was speaking at an industrial workshop on nanotechnology organised by PHANTOMS, a network supported by the Esprit programme he chairs. It was held at IBM's Zurich Research Laboratory, where Gerd Binnig and Heinrich Rohrer invented the scanning tunnelling microscope (STM). The STM is to nanotechnology what the telescope was to astronomy, and won the pair the 1986 Nobel Prize for Physics.

Nobel laureate Heinrich Rohrer "Do we really need pentabit devices? Or would we be better off pursuing higher complexity, instead of smaller transistors?"

Almost every speaker at the workshop had a different angle on nanotechnology. For Harold Craighead of Cornell University, it includes the precise control of individual biological molecules, propelling biochemistry into "a new regime where an enormous potential remains largely untapped". Peter Vettiger of IBM-Zurich, on the other hand, demonstrated the 'millipede', a prototype of a revolutionary - and purely mechanical - data storage device.

The difficulty of pinning down a useful definition for nanotechnology can even be found in PHANTOM's full name - Physics and Technology of Mesoscopic Systems. Mesoscopic?

"Mesoscopic fills the gap between the atomic and micrometer scales, where quantum mechanical effects come into play," Van Rossum explains. "Arguing about definitions may seem pedantic, but if you cannot define a science how can you run a research programme?"

Nanoelectronics: Driving Force

The arguments may continue, but it is certain that for the last decade the driving force in the field has unarguably been nanoelectronics - by any definition the future of the microelectronics industry.

This emphasis — widely supported by the Esprit Programme at the European level - was natural, as by then the microelectronics industry had looked ahead and seen serious challenges for its cherished CMOS [1] process.

CMOS technology has been refined for over 20 years, driving the 'line width' - the width of the smallest feature in an Integrated Circuit (IC) - down from 10 to 0.25 microns. This is the force behind Moore's Law, which predicts that the processing power of ICs will double every 18 months.

This cannot continue indefinitely. Early next century, feature sizes will enter the mesoscopic range of under 0.1 microns (100 nanometres), where a number of serious problems await. Some of these problems are 'merely' technological - it becomes increasingly difficult to manage heat dissipation from circuits as they get closer together, for example, while the cost of semiconductor production facilities is expected to exceed US$5 billion by 2006 (see table, p.6). Eventually, however, CMOS may hit a more fundamental barrier - the quantum world. How does one design a circuit which is so small that Heisenberg's Uncertainty Principle becomes a factor?

In 1997, therefore, Esprit responded with the 25 million euros Advanced Research Initiative in Microelectronics (MEL-ARI) under its 'Long-Term Research' activity.

"MEL-ARI aimed to pave the way for a quantum leap to a new generation of computing devices," says Esprit Officer Kostas Glinos. "It is in fact two project clusters - one focusing on optoelectronic interconnections, the other on nanoscale IC production techniques."

There are 13 projects in the second cluster. All concern radical advances in chip technology that could impact memories and logic processors early next century, including single-electron electronics, molecular electronic devices, nano-imprinting techniques, quantum ICs and nanoscale interconnects (see "Drawing the finest line", p.6). There are also two associated projects on nanoscale resists and vertical CMOS.

A New Paradigm?

Since MEL-ARI was launched, however, a number of more radical ideas have come off the science fiction bookshelves and into serious discussion. "New computing and manufacturing paradigms are being considered, and the field is starting to feel more multidisciplinary," says Glinos. "We're not just talking nano-electronics any more, we are talking about molecular scale processing in general, whether it be electronic, mechanical, biochemical or even quantum in nature. We have to establish a vision of systems, not just devices."

This, according to IBM Zurich Nobel laureate Heinrich Rohrer, is about time. "The paradigm of the microelectronics industry is not the way forward," he argues. "We can only miniaturise two more orders of magnitude before we reach the atomic level, and it will cost an absolute fortune. Do we really need pentabit devices? Or would we be better off pursuing higher complexity, instead of smaller transistors?"

Rohrer points to biological systems as a better paradigm. "Natural systems do a lot of processing at the periphery, and only transmit useful information - not raw data - to the centre," he observes. "They achieve this through 'integrated complexity' - combining physics, chemistry, biology and electronics. That's why we need greater multidisciplinarity in tomorrow's research programmes."

The time is right

Glinos agrees with Rohrer that more interdisciplinary research is needed. So has the EC's view of nanotechnology evolved? "It is time to get more adventurous," he says firmly. "The nanoscale research has to result in some revolutionary feature, or provide new functionality. The reason is clear. We are unlikely to ever make atomic-scale patterns using today's top-down approach, so we will need bottom-up fabrication techniques, such as self-assembly. But these techniques are not faultless, so we will need to adopt the fault tolerance and fault detection architectures found in biochemical systems."

In the new interdisciplinary structure of the Fifth Framework Programme, therefore, nanotechnology will no longer be only nanoelectronics (see box, page 7). "This shift in thinking was a matter of timing", says Glinos. "We have had 'exotic' projects in the past, but we could never achieve critical mass because the field was too immature, there was not enough demand from science and industry. Today, however, the time is right."

(1) CMOS - complementary metal oxide semiconductor, the basic process used in the microelectronics industry.

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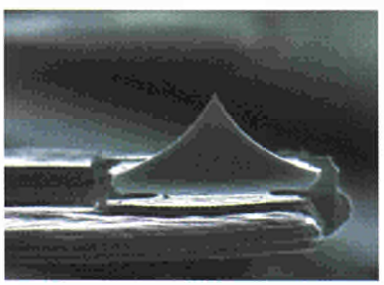
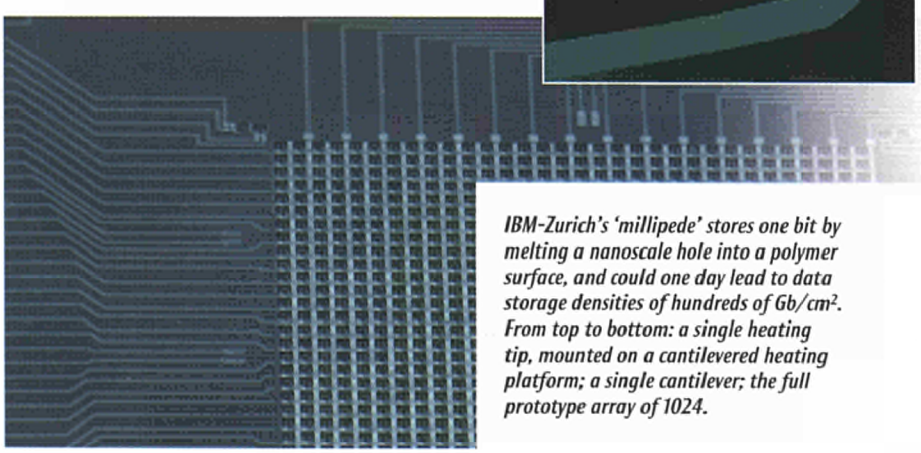




IBM-Zurich's 'millipede' stores one bit by melting a nanoscale hole into a polymer surface, and could one day lead to data storage densities of hundreds of Gb/cm². From top to bottom: a single heating tip, mounted on a cantilevered heating platform; a single cantilever; the full prototype array of 1024.

Drawing the Finest Line

NANOWIRES project has developed key insights into the behaviour of molecule-sized wires in integrated circuits.

One of the key bottlenecks in the road to nanoscale ICs is the interconnects - the wires connecting each element of the chip. Sub-100nm circuitry will require interconnects from 50nm in size down to molecular and even atomic dimensions, where our current understanding of basic phenomena such as electron conduction fails.

The NANOWIRES project was launched under the Advanced Research Initiative in Microelectronics (MEL-ARI) to improve that understanding and study potentially useful molecular systems. Led by the University of Cambridge, it brings together research institutes from Denmark, France, Spain, Sweden and Switzerland.

"There are two basic varieties of nanowire - metallic and molecular," explains Veronique Langlais, a young French researcher who joined IBM-Zurich near the start of the project. "We're working with molecular wires and switches because they have a couple of key advantages. For one thing, when you use a specific molecule as a wire, you know exactly what you've got, there's perfect reproducibility. And so-called 'smart molecules' can be designed to be self-docking - they literally put themselves in place on the chip. It beats doing it manually!"

End of the Line for Moore's Law?

Year of first DRAM shipment	1995	1998	2001	2004	2007	2010
Bits / Chip	64M	256M	1G	4G	16G	64G
Minimum feature size (mm)	0.35	0.25	0.18	0.13	0.1	0.07
Power dissipation (Watt)	80	100	120	140	160	180
Cost of a fabrication facility	$1Bn					$5Bn

In A Spin

The front cover of last July's edition of Science [1] featured an unexpected result from Esprit's NANOWIRES project - a molecular wheel, spinning at very high speed. Designed and synthesised by IBM Zurich and CEMES, this self-docking molecule - hexa-butyl decacyclene (or HB-DC) - is propeller-shaped and has a diameter of about 1.75 nanometres. "We were studying molecular switches, using a voltage pulse from an STM tip to trigger a reversible change in HB-DC," recalls James Gimzweski, in charge of nano-engineering at IBM Zurich. "One day we saw a ring where a molecule should have been, and eventually figured out that we were looking at a molecule of HB-DC spinning at a fantastic rate."

They found that a tiny irregularity in the substrate allowed the molecule to move sidewise by around 0.25 nanometres. This was just enough for it to escape the immobilising grip of four molecules surrounding it on one side, while a fifth molecule on the other side stopped it from drifting further away. These five molecules basically created a nano-bearing, allowing the central molecule to spin. The thermal energy at room temperature was enough to get the molecule spinning.

"It works in a dry state and appears to be wearless, so it has many advantages for creating gears and motors at the nanoscale level," Gimzewski points out. "Wheels such as this may someday become the smallest conceivable components of molecular engines."

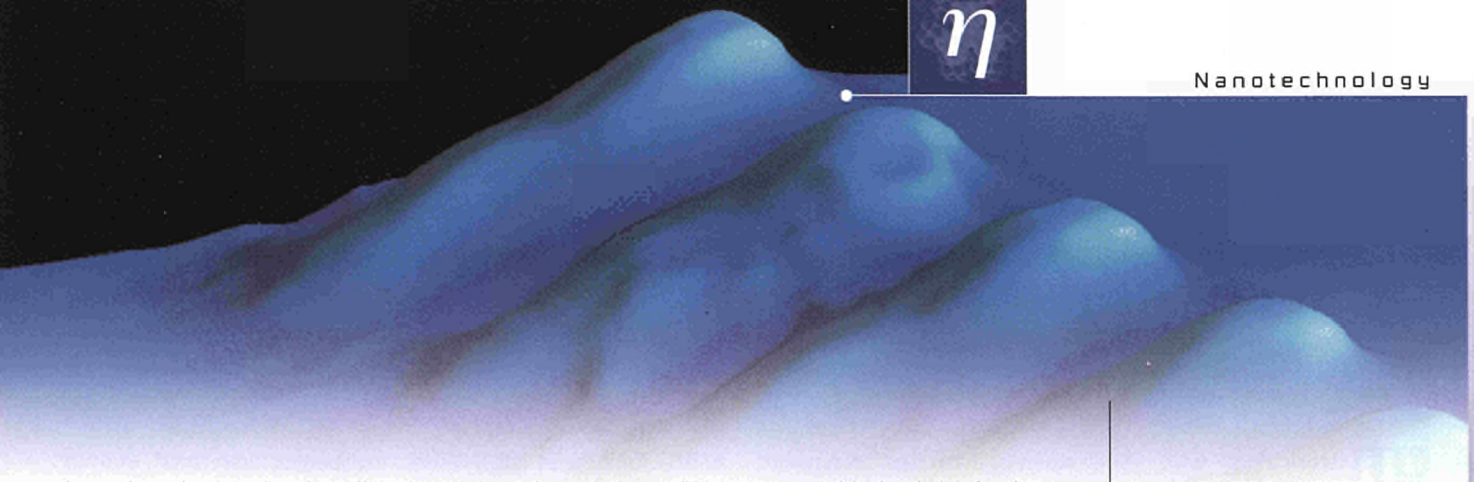
(1) Science, July 24, 1998.
http://www.sciencemag.org/content/vol281/issue5376/

Lander has Landed

IBM-Zurich worked with one of their NANOWIRES partners - Toulouse-based CEMES (Centre d'Elaboration de Matériaux et d'Etudes Structurales, part of France's CNRS) - in custom-designing a molecular wire using special modelling software. CEMES successfully synthesised it around the time NASA's Pathfinder Mission reached Mars. That, plus its appearance, led the team to christen their new molecule 'Lander', after the Mars Rover.

Composed of around 200 atoms of carbon and hydrogen, Lander is 1.7µm long, 0.3µm wide and sits on four insulating legs which keep it 0.6µm off the substrate to which it is fixed. The researchers' aim was to study its ability to conduct electrons, so they were astonished to find that their new pet was smart.

"The way Lander turned out to be self-docking was an added bonus. Basically, if there's an IC element on a chip with an electrode that is the right height



Computer analysis of this 3D scanning tunnelling microscope (STM) image of an array of self-docking nanowires has provided crucial information regarding the way they transport electrons.

above the substrate, Lander will attach itself to that electrode," Langlais continues. "So if you want to use Lander to link two IC elements together, you have to make your IC elements with the right electrodes, and place them so that they face each other across a gap of the suitable width. Lander will find the spot by itself."

Tunnelling the Charge

And what then? After all, the key question was how well molecules like Lander can carry electricity across that gap. "Lander is not a conductor, at least not in a classical sense," Langlais acknowledges. "But electrons travel along a nanowire - by quantum tunnelling."

Charge flows between the two electrodes because the metal wave function of the electrodes leaks into Lander, thereby extending its penetration length. This allows electrons to 'jump the gap' without physically passing through Lander at all, in accordance with Heisenburg's Uncertainty Principle.

The team not only made the first experimental confirmation of this phenomenon, they derived a quantitative value of the Tunnel Barrier height in Lander. In addition, they showed that even when the nanowires were laid cheek-by-jowl, current did not leak from one to another - an important finding, as it would allow high density nanowire arrays.

"We might change Lander's Tunnel Barrier by physically squeezing the molecule with an STM," Langlais adds. "And that opens up the possibility of molecular transistors. Similar work by our team led to the discovery of the electromechanical C60 amplifier and the spinning molecular wheel [see box], so the lines between nanoelectronics and nanomechanics are blurring fast." ■

Nanotechnology in FP5

Information Society Technologies programme. Some 10% of the IST Programme's resources will be set aside for Future and Emerging Technologies, where the risks, timescales and stakes are high. Around half this budget will be open to all information society technologies.

The other 50% will be dedicated to several Proactive Initiatives - project clusters in the same vein as MEL-ARI — in fields such as nanotechnology, quantum computing/communications and bionics.

Quality of Life and Management of Living Resources programme. While the previous Biotechnology programme included the interface of structural biology with electronics and funded projects combining bioengineers and material engineers,[1] the new concept of **"nanobiotechnology"** may be included, in particular in the Cell Factory key action, and focus on the application of new scientific tools to biological systems and, the use of biological systems as tools in the development of new products / technologies. Finally, the **Sustainable and Competitive Growth** programme may fund nanotechnology in two areas - under the Key Action on 'Innovative Products, Processes and Organisation', which aims to develop new and improved methods of design, advanced equipment and process technologies, and under the programme's Generic Research actions, particularly those focusing on new materials, surface engineering, measurements and biomaterials.

(1) The recent "EC-US report on nanobiotechnology" is available from Philippe de Taxis du Poët (EC Biotechnology programme) or on the web at: www.bio.cornell.edu/nanobiotech/nbt.htm.

Diversity, convergence, cohesion

Can regions which lag behind in the S&T race catch up? If so, can S&T investment be translated into economic growth and job creation?

This article is the third in a series which RTD Info is devoting to the "1997 European Report on S&T Indicators" (ERSTI).

"Historically," note the ERSTI report authors, policy makers believed that regional variations in technological development have a, "significant impact on the growth in economic disparity between the regions in Europe."

This "linear" view – held by those who thought that any investment in research automatically results in applied development, commercialisation and job-creation – held sway in the 1980s, but is now widely questioned. Spending in technologically, "underdeveloped" regions, very often does not produce a local economic benefit. "Moreover," says the report, "these small high-tech firms [those resulting from S&T investment] represent a low percentage of the SME population."

"Modern regional technology policy," the authors argue, "should therefore involve a framework to meet the needs of local SMEs in technology adoption and product innovation." If this is to be successful, an understanding of regional variations in S&T capabilities – and the reasons for these differences – is required.

Regional Disparities in Europe

Europe suffers from an S&T "cohesion gap". The cohesion gap is, in effect, a comparison of S&T funding, as measured as a percentage of GDP. As the authors point out, "In 1993, Sweden allocated the highest percentage (3.04%) of GDP to R&D activities. Greece brought up the rear with 0.66%."

Such contrasting positions led the authors to monitor the evolution of this gap and to develop the notion of a "cohesion paradox". In other words: is it feasible for a deprived region to catch up? Or, "Can poorer regions overtake richer ones; can less technology-intensive regions become high-tech, taking the position of the classic industrial cluster in Europe, and will Europe evolve towards a cohesive block in economic and technological terms?"

The latest statistics (1993), lead the authors to conclude that, from 1989-1993, there was some narrowing in the technology gaps. However, the gulf remains significant. One explanation for this could be the "twin peak" theory proposed by some academics, "...in which a group of the rich and a group of poor regions form two convergence clubs." If this hypothesis holds, you can come top of the second division, but you can never be promoted to the first.

The authors find no easy correlation between the progress made by a region and the amount of EU funding received. They conclude that, perhaps,

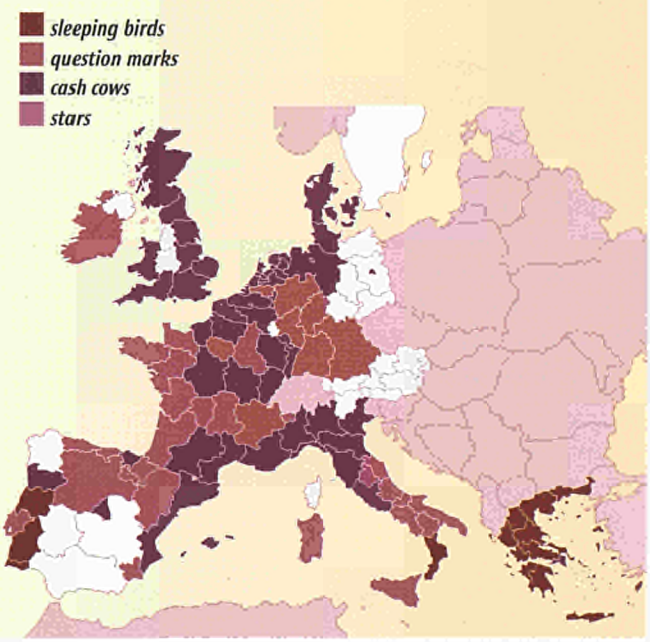
Mapping S&T in Europe: Four Types of Regions Emerge

■ The **Sleeping Birds** (13 regions). Regions that are predominantly agricultural, show low economic growth, have limited technological activity and low unemployment. Total participation in Third Framework Programme funding is around 2%.

■ The **Question Marks** or **Wild Cats** (33 regions). Characterised by being largely rural, showing some technological activity, but facing high unemployment rates. They account for approximately 12% of the Third Framework Programme.

■ The **Cash Cows** (56 regions). The heartland of the European economy. Highly industrialised, showing low economic growth and average unemployment rates. These regions applied for over 50% of projects under the Third Framework Programme.

■ The **Stars** (8 regions). The European S&T leaders. Fast growing, technology intensive with low unemployment rates. They account for 22% of the Third Framework Programme.



"Europe plays an important conditioning role in supporting cohesion, but its policy can only be effective if it is complemented by member state actions."

The laws of diffusion

Analysing the performance of those "second division" regions which have performed well, two major factors become apparent, "...these regions belong to a country with a well-elaborated innovation system," the authors find, "and each of them is geographically located close to absolute leaders." S&T, it seems, is subject to the laws of diffusion. The authors point out that statistics are not always comparable. A region which doubles its output of patents from two to four and then four to eight in successive years, is not to be held up as a success against a region which produces a lower percentage growth, but claims many times as many successful applications.

There have, however, been some illustrations of progress. "The new [German] Länder are the most prominent example," the authors disclose. "Other cases include: Ireland, and Algarve, Alentejo and Centro (P)."

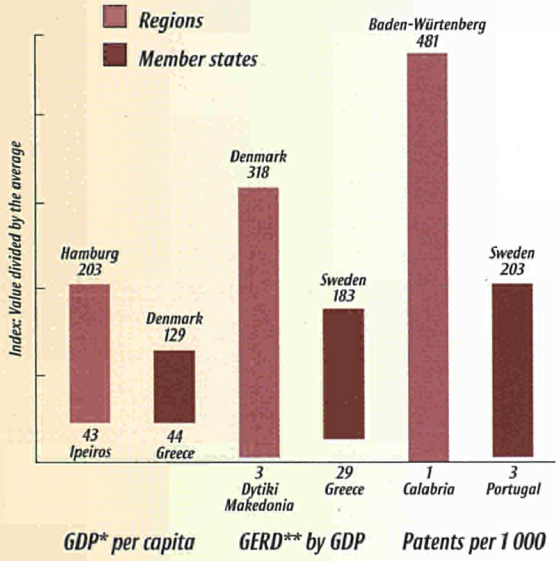
Mapping Performance Levels

Using a statistical analysis technique known as clustering, based on carefully defined indicators, the authors identify four distinct levels of regional S&T performance (see box). In the clustering technique, groupings are not predefined: the classifications emerge as a result of statistical analysis. Only then are they given the appropriate label. The four groups cover the majority of Europe's regions.

The biggest remaining question is, how does Framework Programme funding affect the landscape of European S&T? The authors find that it "...contributes only a fraction of overall RTD spending ... direct impact on technology creation should not be over-estimated." On the other hand, "Framework Programmes, in contrast to national technology policy actions, focus on [international] technology transfer in the form of RTD collaboration."

Finally, the authors assess what is needed for RTD collaboration to be effective in stimulating economic activity, urging integrated policies to improve absorptive capacity. This implies the need for consistent economic, social and educational policies, designed to create an environment where local industry can benefit from the RTD activities. ■

The technology and cohesion gap in Europe: regions versus member states (1994)



Source: DGXII-A54, Data: EUROSTAT

203 for Hamburg indicates that this region has twice the average GDP per capita. Alternatively, Ipeiros has less than half the EU average.

** GDP: Gross Domestic Product ** GERD: Gross Domestic Expenditure on R&D*

ERSTI Contents

The Second European Report on S&T Indicators (ERSTI), published by the Commission in December 1997, is a unique and massive collection of data and analyses on every imaginable aspect of science and technology in Europe compared with the rest of the world.

Part I – European Science and Technology in the World
Part II – From R&D to innovation and competitiveness
Part III – European diversity, convergence and cohesion
Part IV – R&D co-operation in Europe
Part V – The European Union as world partner

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Let the train take the strain

Shipping freight by rail needs to be made more competitive to ease the pressure on the roads. A European research project has demonstrated an innovative approach to the automated, intermodal shipment of goods that is both practical and profitable.

Goods transport by road currently accounts for more than 75% of the total freight market. Since 1970, it has grown by 150%, while rail freight has fallen from 32% to 12%. If this trend continues over the next decade, rail will represent less than 9% of the total freight market, which is expected to grow 30% over the same period.

This increase in road transport is causing an increasingly evident congestion on the roads, with a very real impact on the environment. A European alternative is needed - one which is commercially viable for as many routes as possible.

One way of achieving this is to make goods transport by rail more attractive, in particular by integrating rail as much as possible with other modes of transport - such as road, air or sea - without changing container, thus effectively providing a competitive door-to-door service. The method is known as "intermodality". At present it is of no more than marginal importance, due to the high cost, lack of flexibility and sometimes complex organisation which limits this type of transport to major operators moving freight over distances of 500 kilometres or more.

Horizontality

One action designed to tackle this problem of integrated transport (rail, road, air, sea, canal) is the FLIHTT (Flexible Intermodal Horizontal Transhipment Techniques) cooperative project, supported by the Brite-EuRam programme. "Vertical transhipment - that is the loading and unloading of goods by lifting them from one mode of transport to place them on another - currently represents between 92% and 95% of the intermodal market," says project coordinator Fabio Magni, managing director of the Costamasnaga Group, European leader in the production of intermodal equipment and wagons. "We are convinced that an interoperable horizontal technique - which consists of automatically sliding freight units from one mode of transport to another - can yield substantial cost reductions and thereby win a significant market share for intermodal transport." (1)

A horizontal transhipment system, compatible with most terminals and permitting easy and economic automation.

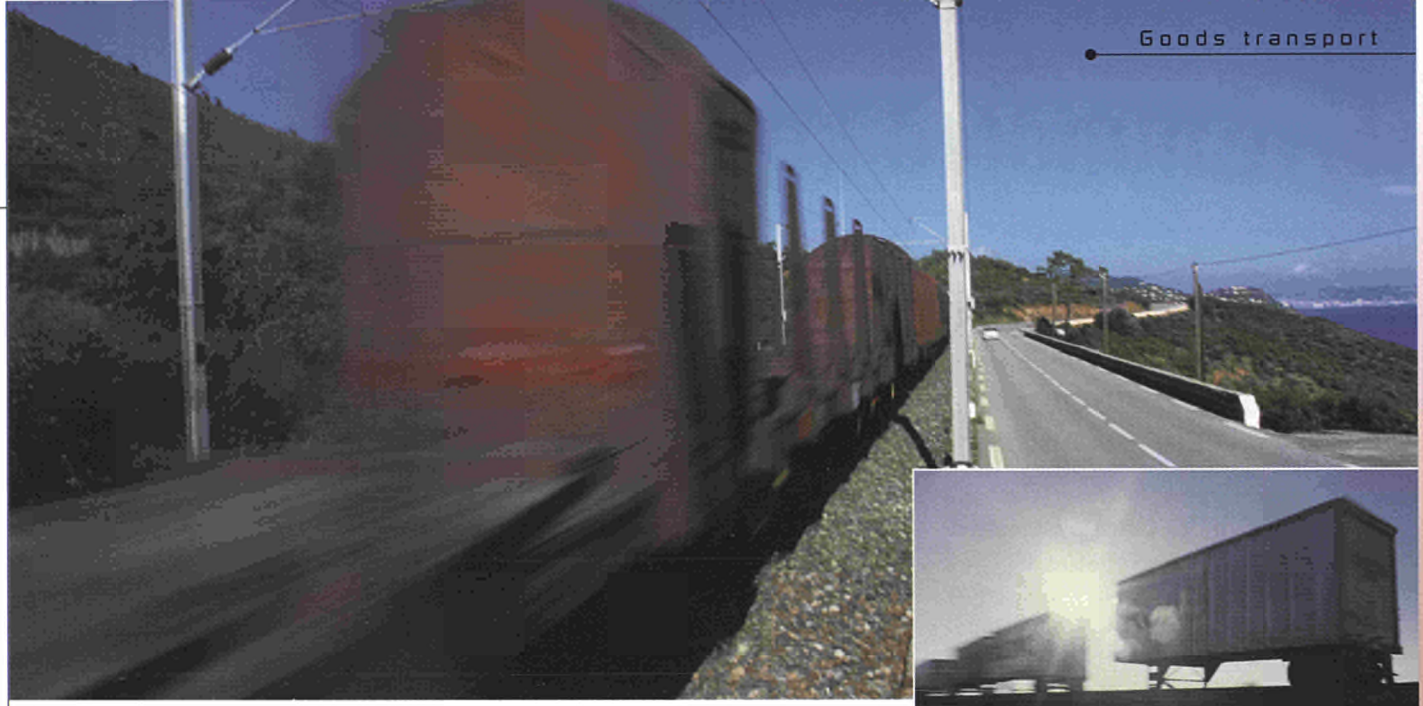
Easy to say, but it had to be demonstrated in practice. The idea convinced the Italian railways, the ENEA research institute (Italy), the French engineering company Technicatome, the Universidad Politécnica of Madrid (Spain) and Kranservice, a German firm producing transhipment equipment. In 1996, they teamed up in order to study the European applicability of TRAI-2000, the "laboratory" of the horizontal transhipment system developed and produced by Costamasnaga for the Italian Ministry of Trade, Industry and Innovation. The reason for the cooperation is clear: after all, what good would a system be unless it worked at a majority of European terminals.

Compatibility

In fact, the main obstacle to genuine interoperability of a "door-to-door" delivery system lies precisely in this lack of compatibility. A change of transport mode en route is more of a complete change of system than a simple transhipment. "The associated costs have major consequences for competitiveness, not to mention delivery times, restrictions regarding the type of merchandise, or complex administrative procedures."

It is in this area that the technique developed by the Italian engineers proved particularly innovative. Whereas most horizontal systems of rail transhipment are limited to a specific client, a precise geographical market, or a single product, the Italians focused on compatibility with road transport and its logistics, with air transport, and above all with vertical intermodal transport (mobile containers and crates). "The objective is not to harm the vertical monopoly, which it would be difficult for us to do anyway. On the contrary, it is preferable to arrive at a simple and flexible system based on complementarity with different systems and existing freight units."

The TRAI system, patented several years ago, consists of a modular tray on which the freight units - pallets, containers, crates, etc. - are placed, ready for automatic sliding into a goods wagon, for example, or mechanical sliding from one system of transport to another, such as at the docks. The original feature of this system is that the sliding is at the head of the wagon. This is sometimes seen as a weak point, the convoy having to be divided up into separate wagon trains on one or more platforms. "Just a few minutes work, carried out by two operators and we have a solution which allows the complete automation of the logistic operations," explains Fabio Magni. "The disadvantage, if there is one, remains minor compared with the benefits confirmed by the European technico-economic feasibility study."



Freight is set to grow by 30% over the next decade. But rail is likely to account for no more than 9% of the total market.

Intermodal transport is competitive over distances of above 500 kilometres. The results of the FLIHTT project should more than halve this distance.

Feasibility

The first stage of the feasibility study involved analysing existing technologies in order to ensure the new system's interoperability with as many terminals and loading units as possible. "There simply are no goods wagons which can adopt this horizontal system without having to be adapted in some way. We therefore based our work on two types of wagons - platforms and covered - in order to adapt the sliding system, define the modifications to be made to the wagons and ensure that all existing loading units are compatible with the systems used."

Transhipment operations are difficult to automate due to the many types of goods wagon and loading units in service. "But this system permits easy and economic automation, in two dimensions rather than three, while remaining easy to install in a limited space."

It remained to be seen to what extent TRAI-2000 would be able to penetrate the market. The second part of the study therefore focused on how it could be used at the terminals in Padua (Italy) and Lille (France). "In general, intermodal transport becomes competitive over distances of more than 500 kilometres. But even if we include the costs of technical changes, our system can be efficient for journeys of under 200 kilometres, which means the majority of goods transport between border regions and European towns."

And the cost per movement would fall from 20-27 euros to around 7 euros per freight unit for a terminal with a capacity of 150 000 units per year, for example. The investment in infrastructure is 40% to 60% less than in the case of vertical technology and management costs between 30% and 40% less. Which means about a 30% faster return on the investment.

A good deal? No doubt. "But marketing it remains difficult," concludes Fabio Magni. "Any innovation, however small, which threatens to upset the status quo is regarded with great suspicion in the industry, even if the current situation does not always meet market needs. Vertical intermodality took around 20 years to become established as the norm, and the same will no doubt be true for its horizontal equivalent."

On project completion, the European team handed over to a new Italian consortium, which will be selecting and locating terminals and logistics operations, allowing the system to be implemented in Italy, probably in around 2001-2002. First Italy, then Europe? ■

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(1) Horizontal unloading is not a new idea: milk containers were already transhipped between flat goods wagons and lorries in the UK in the 1930s. It is also the principal system used for loading lorries at factories or freight airports.

Five hundred kilometres with zero emissions

Resulting from one of the many European projects to develop clean vehicles supported by the JOULE programme, FEVER is one of the first prototypes of an electric car powered by a fuel cell, which consumes only hydrogen and atmospheric oxygen. With a range of 500 km, its top speed is 120 km/hour.

"In 15 to 20 years time, 75% of cars on the road will consist of hybrid vehicles, in which electric power is coupled with an internal combustion engine. The remaining 25% will be fully electric," Gaston Maggetto confidently predicts. A lecturer in electrical engineering at the Université Libre de Bruxelles, he is also president of AVERE (the European association of electric road vehicles) whose 500 or more members include research centres, car companies, energy suppliers, parts manufacturers and users.

From 29 September to 3 October this year, AVERE and its US and Asian counterparts held the 15th worldwide electric vehicle symposium (EVS15). The star attraction at this gathering of the experts was the French manufacturer Renault with the first public presentation of the FEVER demonstration vehicle - one of the first experimental electric vehicles with an engine powered by a fuel cell. FEVER is the result of a European project, coordinated by Renault, which began in 1993 and ended last June.

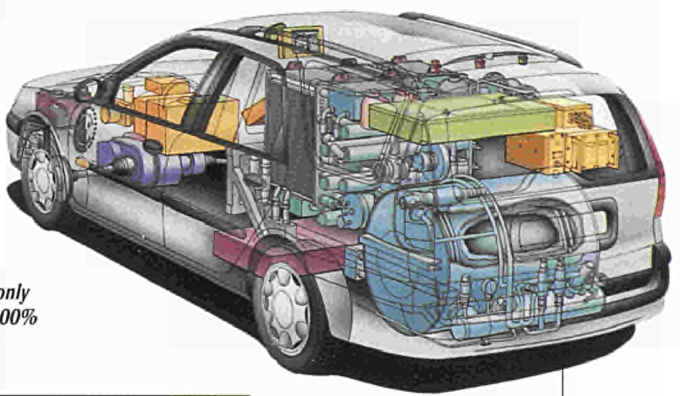
Electrolysis in reverse

"The fuel cell principle is the reverse of electrolysis, in which a current causes water to break down into hydrogen and oxygen," explains Jean-Claude Griesemann, who leads the research at Renault. "In a fuel cell, it is the recombining of hydrogen with the oxygen in the air which produces an electric current and water." With the aid of a catalyst, the hydrogen introduced into the first chamber in the fuel cell releases electrons, which are captured by a metal plate resulting in an electric current. The hydrogen nuclei - or protons - then pass through a semi-permeable membrane and recombine, in the second chamber, with the oxygen in the air. The water thus formed is the only waste produced by this 100% clean system of energy production.

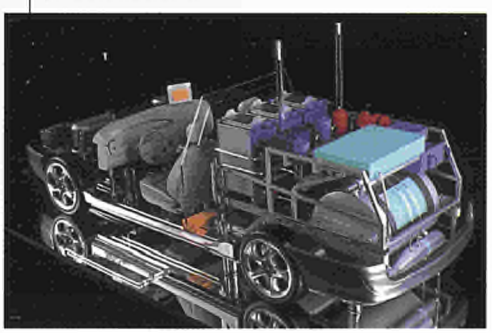
Renault's partners on the FEVER project were the Italian companies De Nora (responsible for fuel cell production) and Ansaldo (assembly of secondary systems and hydrogen tank with the fuel cell), Air Liquide of France (manufacture of the hydrogen tank), Volvo of Sweden (simulations) and the Paris School of Mines (definition of the system's operating parameters). "The main problems were in understanding the physical phenomena which take place inside the system," explains Jean-Claude Griesemann. One of the difficulties is in maintaining the balance between the pressures of air and hydrogen (3 atmospheres) on either side of the membranes during all the transitional stages. Any sudden imbalance could break the membranes - and thus destroy the cells. Another difficulty is linked to managing the water, both that required for gas humidification and cooling and the water produced by the fuel cell. Too much water in the circuits would prevent proper gas circulation for example. Temperature control is also a problem, because any heating means energy consumed at the expense of electricity production."

The lessons of a prototype

The experimental vehicle, which used a modified Renault Laguna estate, demonstrated the feasibility, and above all the



Fuel cell developed by the FEVER project. The only waste emitted by this 100% clean system of energy production: water.



Two problems remain to be solved: size and cost.

qualitative and quantitative performances, of such a system: zero emissions, much higher energy production than for internal combustion engines, a top speed of 120 km per hour and a range which is limited only by the quantity of hydrogen carried (500 km for 8 kg of liquid hydrogen). The remaining problems to be solved prior to industrial production are space (the system's current size only leaves room for two passengers) and cost. "The project was launched five years ago," pointed out the Renault director, "and the fuel cell provided by our partner De Nora reflects the state of the art in 1995. Since then, fuel cell sizes have been reduced four times. Now we are also beginning to master the technologies needed to reduce fuel cell cost." The objective viewed as economically reasonable would be to get down to 100 euros/kw, which is equivalent to twice the price of the engine - some good quality fuel cells at present cost up to 100,000 euros/kw.

Ongoing European support...

In addition to working on the FEVER project - a great success at the EVS15 show - Renault, De Nora and Air Liquide are also cooperating with other partners on the EU's HYDRO-GEN project. Coordinated by the French car manufacturer PSA, this aims to develop another type of vehicle using a new generation of fuel cells and compressed hydrogen. "It is becoming increasingly likely that in future the centre of a number of major European towns will only be accessible to vehicles with zero polluting emissions. I am convinced that fuel cells will have a great future after 2010," believes William Borthwick, the scientific officer responsible for the project at the European Commission. In addition to HYDRO-GEN, European programmes are also supporting projects such as FCBUS (the fuel cell bus), coordinated by Air Liquide, and CAPRI, an initiative coordinated by Volkswagen which is based on a new method of hydrogen supply.

The mass production of this explosive gas, together with its transport and distribution, is in fact one of the main obstacles to use of the fuel cell. Manufacturers are therefore looking at the possibility of producing the hydrogen directly in the vehicle itself by means of a "reformer". A common operation in gas industries, reforming involves oxidising a hydrocarbon, using high-temperature steam and air, and a catalyst, in order to obtain hydrogen, carbon monoxide and a lighter hydrocarbon. With methanol, the reformer produces hydrogen and carbon dioxide only. "This solution has the advantage that it can be used immediately in the existing distribution network," points out Gaston Maggetto. "Methanol can also be produced from very diverse sources. Vehicles designed in this way would no longer be zero emission, but the system's excellent energy efficiency would still result in a major reduction in the CO_2 emissions of these vehicles. In any case, producing large quantities of hydrogen would mean building a power station somewhere."

An experimental vehicle, modelled on a Renault Laguna estate.

... in the face of vigorous competition

For Renault, as for a growing number of motor manufacturers, the electric vehicle is an important part of development strategy. "And if we forget," remarks Jean-Claude Griesemann ironically, "Toyota's Prius will remind us." While the major obstacle to the growth of the electric vehicle market is its price, the Japanese manufacturer is on the point of launching a hybrid vehicle, first in the US and then in Europe. It attracted a lot of attention at EVS15 and costs no more than a traditional vehicle.

That said, users must still accept this radical change in technology. "In the medium term, the future of the electric vehicle will partly depend on the acceptance of the city-car concept," points out William Borthwick. Following EVS15, a very special kind of rally took a group of electric vehicles from Brussels to Monte Carlo, stopping off to give a demonstration in some 15 towns along the way. The trip (in which bicycles also took part, proving particularly effective when crossing the snowbound Saint Gothard pass) was an opportunity for the public to take a closer look at these "eco-vehicles". ■

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News in brief

Conference to launch the Fifth Framework Programme 1999-2002

Essen (Germany), 25-26 February 1999

A radical departure from its predecessors, the Fifth Framework Programme provides the framework for the strategic planning which will guide the allocation of EU financing to support research over the next five years. It aims to help the Union's research centres and companies to meet the challenges of the 21st century and, through multinational research, to provide answers to the major issues facing European society, such as employment and competitiveness, health, the environment, the future of the information society, and mobility.

The Essen conference is designed to present the new direction the programme is now set to take, in particular the multidisciplinary nature of the key actions, which are such an important part of it, and to explain to interested scientific, industrial and institutional parties how they can participate. This two-day event will also allow present and potential research project coordinators to obtain full and up-to-date information and to establish contacts with a view to making a joint response to the calls for proposals, which the Commission will be launching early in 1999.

The conference programme includes:

- a presentation of the seven, new European research programmes which make up the Fifth Framework programme;
- a presentation of some particularly successful research projects by the project leaders themselves;
- a series of practical workshops enabling potential coordinators to find out how to participate;
- an exhibition of the many research projects supported by the European Union, as well as stands for the various programmes, enabling participants to establish direct contacts with current participants, potential partners and Commission officials.
- A cyber-café and electronic bulletin board system will also enable conference participants to make contacts, look for partners, place advertisements, etc. An Internet site set up specifically for the Conference will relay the debates.

Practical information

Conference venue
Messe Essen, D-45001 Essen, Germany
Tel: +49 201 72 44 282
Fax: +49 201 72 44 500
Simultanean interpretation in English, French and German in all sessions.

Registration and organisation
Joint Interpreting and Conference Service
Fax +32-2-295 37 36 or +32-2-296 49 92
E-mail: 5pc.essen@scic.cec.be

Scientific programme
Communication Unit, DG XII
Tel: +32 2 295 99 71, Fax: +32 2 295 82 20
E-mail: Michel.Claessens@dg12.cec.be
Information on the Europa server:
http://europa.eu.int/comm/dg12/fp5/conference.html

New groups of experts for key actions

278 independent experts from research, industry, the user community, and the public sector have been appointed to form 17 new External Advisory Groups. These groups will be advising the Commission in implementing the key actions which form the basis of the framework programme. Their initial task, at the end of last year, was to discuss the draft work programmes of the key actions, particularly with regard to their content and the timetable of calls for proposals, the criteria to be applied when evaluating project proposals, and the definition of quantified or other verifiable objectives in order to achieve the key actions' objectives. At a future date, the groups will go on to consider the results obtained with a view to possibly revising or redirecting the work programmes.

Each of these groups consists of between 15 and 25 members, appointed for two years. Their mandate can be renewed once only. They were selected from some 5,000 candidates, taking into account the need for a fair geographical distribution, a balanced representation of the various technological sectors, and a significant participation of women (7 of the 17 presidents are women).

Creation of the European Research Forum

In order to strengthen links between the scientific community and industry, the Commis-

sion has decided to merge two existing advisory bodies on matters of strategy, namely the Industrial Research and Development Advisory Committee (IRDAC) and the European Science and Technology Assembly (ESTA). In future, the new European Research Forum will be the sole advisory body, consulted on questions of strategic importance for the Community's research and innovation policy. It can provide the Commission with the benefit of its advice, either on request or on its own initiative.

The Forum consists of about 60 members, appointed for two years, and including the chairpersons of the 17 external advisory groups. The forum will be equally divided into two chambers: one comprising members from universities and the world of science, and another representing industry, services and end-users. The two bodies will conduct their work independently, but with the option of joint operations. A plenary session bringing together the two chambers will be held at least once a year. Their members will be appointed for a period of two years.

A new structure for DG XII

On 1 January 1999, the Directorate-General for Science, Research and Development - DG XII - implemented a major reorganisation in order to meet the new management requirements of the Fifth Framework Programme, with its research programmes and key actions more effectively.

- Each of the three thematic programmes - Quality of life and management of living resources, Competitive and sustainable growth, and Energy, environment and sustainable development - is now managed by a group of three directors. One is responsible for the coordination of activities and support for the budget and administration, with the other two directors managing the key actions and other research activities.
- DG XII will remain responsible for the framework programme's overall coordination, and will, in fact, manage five of the seven specific programmes as well as the implementation of special measures for SMEs.

In another reorganisation designed to improve coordination within the User-friendly information society programme, the parts of the Commission which previously managed the Esprit, ACTS, and Telematics Applications programmes are now part of the same directorate general: DG XIII - Telecommunications, Information Market and Exploitation of Research.

Publication

- *1998 Annual Statistics for research and development — EUROSTAT - ISBN 92 828 4877 9.* This annual report presenting the statistics for 1998 (R&D expenditure, number of researchers, production of patents, etc.) shows that a total of 140 billion euros was allocated to research and development in the EU, a 3.8% increase on the previous year. This represents 1.9% of the EU's GDP. 60% was invested by companies, the rest consisting of public funds allocated to research and higher education. Germany, France and the United Kingdom account for two-thirds of research expenditure in the Union.

Office for official publications of the European Communities (Eur-OP)
Luxembourg
Fax: +352-292942759
Internet: http://eur-op.eu.int/en/general/s-ad.htm

- *Classrooms for Distance Teaching & Learning: A Blueprint - Leuven University Press (B) 1250 BEF* - An information manual and practical guide for teachers, published by those who participated in the European BIC (Blueprint for Interactive Classrooms) project for two years.

Information: gee.cammaert@linov.kuleuven.ac.be.

Diary

- *Cities for citizens: what local environmental and energy policies* - 22-23/4/99 — Brussels (B). Conference organised by "Energies-Cité" (France).

Contact: Pierre Mathy - DG XII
Fax: +32-2-2963024
E-mail: pierre.mathy@dg12.cec.be

- *Sustainable Development and Spatial Planning in the European Territory: Prospects for the 21st Century in the European Union, its Member States, the Balkans and the Black Sea Countries* - 13-16/5/99 - Athens (G) - Conference organised by l'Université Technique d'Athènes

Contact: Professor L. Wassenhoven
Fax: +301-7721587
E-mail: rpud@upln.ntua.gr

- *Young Scientists' Conference on Marine Ecosystem Perspectives* - 16-20/5/99 — Hirtshals (DK) — Organised by the International Council of the Sea (ICES)

Contact: K.G. Barthel
Fax: +32-2-2963024
E-mail: klaus-guenther.barthel@dg12.cec.be

- *World Sustainable Energy Fair* - 25-26/5/99 — Amsterdam (NL) — Organised by the Community ALTENER programme, this conference will look at the conditions necessary to achieve the objectives proposed by the European White Paper on renewable energy.

Contact: EUROSOLAR
Fax: +49-228-361279
E-mail: Inter_office@eurosolar.org

- *Fourth European meeting on distance working and other distance activities* - 25-27/3/99 - Serre-Chevalier (F) - Organised with the support of DG XIII

Contact:
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Aix-en-Provence (F)
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E-mail: ptropini@systemia.fr

How one research project leads to another

In the exciting field of environmental research, Europe's strategy is determined by the vital need to ensure the widest possible dissemination and exploitation of results. In future, priority will go to funding research projects which build technology or information transfer in right from the outset.

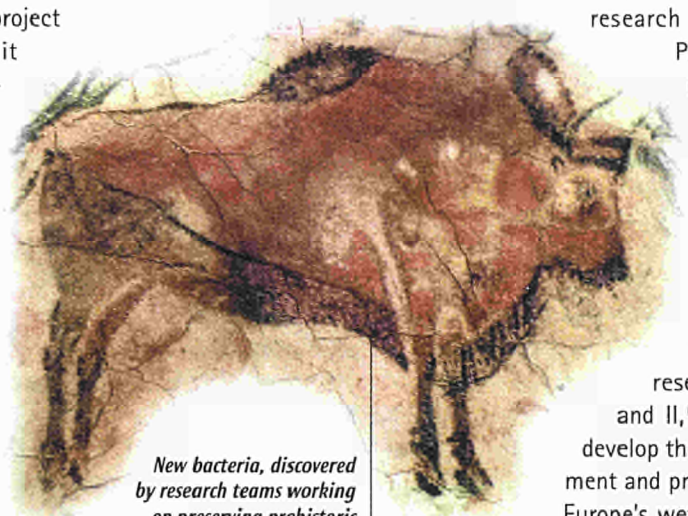
Ecopoly, the "green" version of the famous board game Monopoly, was launched about 15 years ago by a German scientist. Through this game, the researcher was able to increase the level of popular interest in the way ecosystems work. The source of his inspiration was an EU-backed research project in the field of systems analysis, where he was the scientific coordinator.

Such a spin-off from a research project may seem rather exceptional. But it nevertheless symbolises the many offshoots which can and should come from research in the environmental field. "For many years now, the trend in a whole range of projects has been to go beyond the frontiers of scientific curiosity - of knowledge for knowledge's sake - and to consider the usefulness and possible uses of research results," explains Christian Patermann, DG XII's director responsible for key actions focusing on the environment.

This transfer process should be understood in the broadest sense. "Researchers must become aware of the need for scientific results or information to be given all kinds of expression. These may be initial knowledge as a basis for other disciplines, a commercial application, a standard, a directive, or a decision-making tool, for example."

Cross-fertilisation

The transfer from one field of research to another can sometimes take some surprising routes. For example, the Altamira caves in northern Spain are well known for their impressive rock paintings. A little too well-known in fact. Their fragile environment has been changed by opening them up to large numbers of visitors, fitting lighting systems, etc., and generally failing to take the necessary precautions. A project under the Environment and Climate programme brought together a multidisciplinary team to study the problem. Microbiologists analysed the biological colonisation of the cave walls which is causing the deterioration of the prehistoric art. When collected and sent to a laboratory for analysis, these bacteria were found to belong to previously unknown varieties. It was not long before a pharmaceutical company showed an interest in these micro-organisms, which could enable the synthesis of new antibiotics. Cooperation between the two teams of researchers was soon under way.



New bacteria, discovered by research teams working on preserving prehistoric wall paintings, are now attracting the attention of the pharmaceutical industry.

In this case, the cross-fertilisation owes a great deal to chance. The question is, given the vast quantity of data generated by science, how can this knowledge be channelled effectively to those who may need it? And how can you encourage such transfers, when you do not know in advance all the possible outcomes of a particular research project?

Involving the users

"This dimension is central to Community research policy," continues Christian Patermann. "The present trend - one set to become more pronounced - is to involve potential users in research projects at the earliest opportunity."

The PROTOWET [1] project, which will end later this year, is one example of this approach. Following on from the research undertaken by FAEWE I and II,[2] the project's objective is to develop the knowledge base and management and preservation practices relating to Europe's wetlands. Marshes, swamps, peat bogs, flood plains, deltas, and intertidal zones are all ecosystems which present very diverse biotopes. As well as providing unique habitats for rare animals and plants, and leisure areas for hunters and fishermen, they all fulfil essential ecological functions. They absorb surplus rainfall (thereby making it possible to prevent floods), help purify surplus water (in particular by removing nitrates and phosphates of agricultural origin), help regulate greenhouse gases, form part of the food chain, and produce a number of materials useful to man. These and other functions, which are both valuable and free of charge, have rarely been taken into account.

This is why the PROTOWET project is firmly focused on its future users. The wetlands management tool which the researchers are currently developing will be usable by non-specialists and designed to meet the needs of carefully identified users: town and country planning departments, environmental agencies and NGOs responsible for protecting the environment and nature conservation, the European Commission's environment directorate general (DG XI), and international organisations such as the OECD. In addition to management, this tool should also make it possible to implement and comply with national legislation, European directives and relevant international agreements.[3]

The knowledge brokers

Conducting such a project requires dialogue between those who produce environmental knowledge and those who use it. It is very often the absence of an effective interface that limits the dissemination and transfer of research. The parties do not know each other - or at least not well - and tend to think along different lines. There is therefore a need for those who are ready and able to build a bridge between the two worlds.

But could these pragmatic concerns pose a threat to fundamental research? "No," believes Christian Patermann. "In many fields our multidisciplinary knowledge is insufficient. Research must be instrumental in acquiring knowledge. The dissemination of that knowledge, within the scientific community itself, also has an important transfer value."

Getting the message across

Research on environmental change is of vital interest to meteorologists, agronomists, insurance company actuaries, and managers in many economic sectors. This is why the coordinator of the NOURTEC [4] project gives systematic attention to communication. Researchers on this project are experimenting with complex methods for restoring beaches, their findings being principally communicated to members of the scientific community. That way they can be sure that one good idea will lead to another and a multiplier effect result.

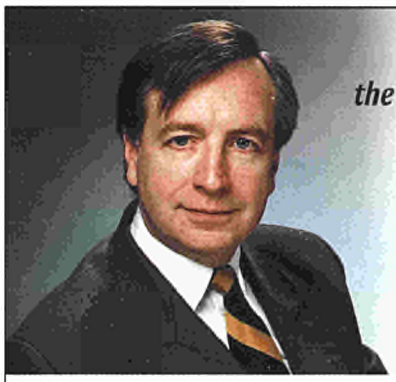
But the dissemination of results must not be limited to the specialists. Under the PEP [5] project, which conducts fundamental research on the functioning of marine ecosystems - which could, in the long term, interest the fishery sector - the project coordinator has also opted for getting the message across directly to the citizen. Local press releases have now been followed by a TV report, presenting the population of these coastal areas with a glimpse of both the life of the scientists and the purpose of their research.

At the same time, technology or information transfer is not only a question of ensuring the most efficient follow-up. As public funds are involved, this information is particularly important in order to justify the way the money is being spent. It also shows that the idea of research for the benefit of society remains essential. "The field of knowledge is vast, the scientific questions many and complex, but our resources remain limited. Choices must therefore be made. Accepting that these choices are not dictated by scientific curiosity alone but also taking society's interests into account is one of the ethical components of research," concludes Christian Patermann. ■

(1) Procedures for the operationalisation of techniques for the functional analysis of European wetland ecosystems
(2) Functional analysis of European wetland ecosystems
(3) Such as Ramsar, the Convention on wetlands of international importance, and the UN Convention on biodiversity.
(4) Innovative nourishment techniques evaluation
(5) Impact of a climatic gradient on the physiological ecology of a pelagic crustacean

Researchers on the PROTOWET project are developing a user-friendly management tool for wetlands, designed for non- specialists.

Fundamental research rapidly applied



The industrial applications of biotechnologies are following increasingly fast on the heels of fundamental research. Eurogene, a company founded on the knowledge gathered by a project under the European BIOMED programme, is a perfect example of this new-found ability to rapidly capitalise on scientific knowledge.

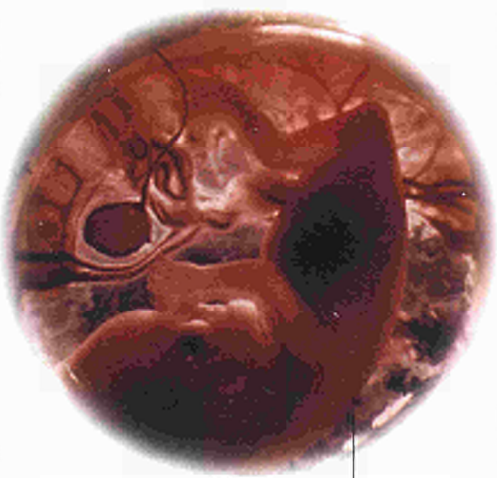
"The originality of our research lies in the possibility of providing local gene therapy fron

In 1996, the Biomed 2 programme came up with 50% of the funds sought by the "Molecular and cellular mechanisms of arterial pathophysiology" project, proposed by a consortium of German, Finnish, Italian and British laboratories and coordinated by John Martin, a researcher at University College London. Their objective was to analyse the molecular mechanisms and signals involved in the process which leads to arteriosclerosis, a major source of the heart attacks and thromboses which are the number one cause of death in Europe.

Detecting the early stages

Hardening of the arteries, caused by the appearance of atheroma deposits, is the result of the migration of smooth muscle cells, present in the underlying layers of the artery walls, towards the internal surface of the vessels. Researchers wanted to study the cellular growth factors and other molecules produced during the early stages of this migration - and thus the proliferation of the cells responsible for the arteriosclerosis. Arteries are very wide blood vessels which need the support of a capillary system (vase vasorum) to ensure efficient oxygenation of the cells in their walls. If this system becomes blocked, the artery can be distorted by the lack of oxygen (hypoxia). It was this process of inflammation which interested the researchers who came up with the hypothesis that it could be the root cause of arteriosclerosis.

Their work led to the discovery that one growth factor, VEGF (Vascular endothelial growth factor), is produced by the smooth muscle cells in a culture subjected to conditions which mimic the hypoxia. Could this VEGF, known for its angiogenic role (stimulating the growth of new blood vessels) in the foetus, perhaps play a role in protecting the arteries? In order to check this, the researchers carried out a gene transfer experiment in order to stimulate over-production of VEGF. This "gene therapy" succeeded in inhibiting, on an animal model, the growth of smooth muscle cells (hyperplasia) within the arterial wall. It was therefore a potential tool in fighting arteriosclerosis.



VEGF stimulates the growth of new blood vessels in the foetus: could it also act as a protection factor for the arteries?

From the patent to the company

After identifying this new role played by VEGF - one very different from the previously known angiogenic role - John Martin and Seppo Yla-Herttuala (of Kuopio University in Finland) registered an international patent describing new potential treatments for arterial complaints. This patent protects the use of all the agonists of VEGF receptors (genes and proteins) used in treating or preventing intimal hyperplasia, in cases when the endothelium (tissue on the interior surface of the vessels) is intact or damaged.

Before the European research project was even completed, the two scientists, working together with vascular surgeon Stephen Barker, decided to set up a cardiovascular biotherapy company. Known as Eurogene, it is a spin-off from University College London. The new and convincing forms of treatment promised by the first results served to attract 4.5 million euro in capital from the London-based company, Merlin Venture.

"The originality of our approach lies in the possibility of providing local gene therapy from the vessel exterior," explains John Martin. "Also our first field of application is surgery. When two vessels have to be connected (anastomosis), such as in heart operations, coronary by-passes or organ transplants, it is important to avoid the later risk of these arteries becoming blocked by hyperplasia. Compared to the alternative of gene transfer through the vessel interior (which can damage the endothelial cells, resulting in a worsening of the patient's condition), applying the VEGF gene at the

"This research is opening up new prospects for the treatment of cancers, surgery involving anastomosis and organ transplants."

outside the vessel walls.”
[John Martin]

site where the problems could occur makes it possible to avoid problems of targeting the particular site and complications linked to the use of viral vectors which are inherent in a blood circulation approach."

The first trials (phase I) to test the treatment for harmful effects have just begun. Phase II tests are due to begin in 1999 in order to demonstrate a possible therapeutic effect. The company, which has an experienced scientific team, is also continuing its search for new treatment molecules based on the discovery of VEGF's action mechanism.

These developments have already allowed the company to widen its patent base by developing a totally original genetic construction, the EG003. "The first in vivo experiments with this construction show that it is possible to insert it into tissues where it is able to fix the therapeutic agents present in very low doses in the blood. This mechanism produces an effective concentration of the therapeutic agent at well-determined sites. Research in this area is opening up new prospects for the treatment of cancers, surgery involving anastomosis and organ transplants."

Another fundamental research project undertaken by Eurogene shows that the energy produced by mitochondria - organelles present in all cells - can be regulated independently of the quantity of oxygen available. The gene responsible for this mechanism is regulated by a patented molecule which the company has been granted a licence to use for applications in cases of muscular fatigue related to Aids, cancer or ageing.

From BIOMED to the stock exchange

50 percent-owned by University College London, the cardiovascular treatment company also helps fund university research. Its development strategy has led it to seek partners in its various lines of research. Preliminary discussions have been opened with two leading US pharmaceutical companies and, given the company's solid scientific capital, it can be reasonably expected to go public within the foreseeable future. "This is truly remarkable progress, so soon after receiving aid under Biomed II," stresses Alain Van Vossel, charged with following up the project at the European Commission.

Eurogene is a genuine model of present trends in biotechnology. It is a field of intense cross-fertilisation between fundamental and applied research, with companies and universities working together in pursuit of common scientific and economic goals. ■

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Demonstrated political will

The research and development carried out under the Biomed 2 "Molecular and cellular mechanisms of arterial pathophysiology" project is an excellent example of the new stress which the Fifth Framework Programme is placing on promoting an early use of the economic and social benefits of research. This new priority is also evident in the research policies pursued by the majority of Member States.

In the field of biotechnology in particular, Europe is now beginning to make up the lost ground which was coming to me a cause of concern, especially in terms of company creation. Following the 1996 deregulation of European financial markets, new financial conditions have made it possible to rapidly attract venture capital to the many new and innovative companies set up by researchers.

Questions of principle

Europe's young researchers have a confident and unselfish vision of the benefits of science and technology. They believe in freedom for research, and think that ethical problems arise not in acquiring knowledge but in applying it. But the conundrum remains: how do we define where the borders of ethics lie?

Edith Cresson with the participants in the Second EU Youth Conference

Idealism is not dead among young people, as Commissioner Edith Cresson discovered at the EU's second Youth Conference, which she hosted in the Charlemagne Building in Brussels from 26 to 28 November. The first Youth Conference, held in October 1997, concentrated on giving feedback to the Commission on the practical organisation of the EU's youth mobility programmes. This year's, which involved 100 participants from 24 countries, took a more philosophical approach. Nearly half those present, predominantly young researchers, chose to participate in the discussions on scientific ethics.(1)

No limits to pure research

The participants' personal motives for taking up research as a career were altruistic: helping society was more important to them than improving their own minds. Half of them even felt science to have a spiritual dimension. But the question of what the ethical limits to science are perplexed them. How can ethical principles be observed without curbing the expansion of human knowledge? In the young researchers' admittedly self-interested view, researchers should be free to research anything, and limits, if needed at all, should only be placed on how new knowledge is applied. Their views are also somewhat contradictory. On the one hand, they acknowledge that the practical and social implications of science and technology place additional responsibilities on scientists. But few of them accept that scientists should be held to account for the negative effects of its use.

Participants displayed unanimous support for an international approach to defining scientific ethics. But who should take the ethical decisions? An expert committee? Parliaments? A referendum? Can we trust the experts, or are they judge and jury in their own case?

Communication and accountability

That bastion of direct democracy, Switzerland, put the question of genetic engineering to a referendum in June this year, and opinion polls predicted a vote to prohibit the creation of transgenic animals, the patenting of transgenic organisms and the release of genetically modified organisms into the wild. But after frantic lobbying by an alarmed Swiss pharmaceutical industry, the ban was defeated by a two-thirds majority. Ethics and communication - some might say manipulation - are thus closely linked.

It would be naive to think that if scientists only took the care to explain what they are doing to the public, they would be left in peace to pursue their enquiries into the nature of the universe free from public accountability. In fact, better communication skills among scientists could actually serve to strengthen, not weaken, the ethical controls on science. As one participant pointed out, at the moment, too many people view science as a speciality, rather than part of the general cultural framework. They therefore feel free to ignore the ethical issues that arise, because they "can't understand the sums". The workshop recommended, therefore, that communications and ethics should both figure in research training curricula. And, democracy being as much about talking as voting, an ethics discussion forum is to be set up on the new Youth Conference website.

There were some happy surprises for these worried souls. It came as a relief to find out that the experts have already been called in, in the form of the EU's Ethics Committee. This twelve-strong body was set up under the Delors presidency to advise the European institutions. Chaired by Mme Noëlle Lenoir, who also presides over UNESCO's International Bioethics Committee, it comprises not just scientists but lawyers, doctors, theologians, and other people with a broad view of ethical issues. The sort of people, in fact, who will be welcome at next year's Youth Conference. ■

(1) The workshop was moderated by Michel Claessens of DGXII, Mary Sharpe of the JRC and Michel Lefranc of DGXXII. The workshop report was delivered by Christiane Böhner, an environmental management fellow at the JRC in Ispra.

Demining: a technological imperative

Europe is committed to the eradication of the threat to human life and limb represented by countless mine fields around the world. Technology has a key role to play in this enormous battle against the legacy of war.

Mines: a curse that must not only be prohibited, but also eradicated from the planet. The European Union, in the vanguard of international action, has proposed that the 120 million mines already laid should be eliminated by 2010. "To meet the objective, it is necessary to carry out demining at least 10 times if not 100 times faster [than at present]," insisted Edith Cresson, member of the European Commission responsible for research, talking at a recent international conference on demining technologies organised at the Joint Research Centre (JRC) in Ispra (I).

At the international level, the European Commission has defined a coherent policy for humanitarian mine clearance with targeted, costed priorities and objectives. Research and technology have a key role in making anti-personnel landmine (APM) detection and neutralisation more effective, cheaper, and faster.

Using part of the additional funding provided by the EU in 1997 for the conclusion of the Fourth Framework Programme, the Commission has launched an 15 million euros research programme for new, safer technologies to locate, identify and deactivate the extremely wide range of mines used all over the globe. Much of this work is being undertaken under the European Commission's Esprit programme, with the active involvement of the JRC.

Fighting false alarms

Current mine-detection technologies are labour intensive, time consuming, expensive, and dangerous for the operators. Visual detection and prodding with a steel or plastic probe are still widely used. Use of metal detectors has declined as about one third of all APMs are now non-metallic – and the amount of metal in battle areas, from spent ammunition to food cans, leads to a high rate of false alarms.

There is an enormous need to release land quickly for peaceful civilian uses, such as farming. As much suspect land could in fact be mine free, better technologies are needed for declaring an area clear – technologies different from those required to locate individual mines. Individual mine location must be as safe as possible; new products should be robust, reliable and easy to use – particularly as many operators will have minimal formal education.

Roads and tracks can be cleared using existing military technology. Civilian solutions are required for agricultural land and built-up areas with collapsed and sometimes booby-trapped buildings. Flat, vegetation-free areas can be tackled by large-scale mechanical methods – such as mechanical flails – which, though highly capital intensive, are cost effective and provide good protection for operators. But all other areas, particularly those covered by vegetation, require some form of hand-held sensor.

Multi-tech approach

Several suitable sensor technologies are already available, including:

- **Metal detectors** – limited by high rate of false alarms and wide use of non-metallic APMs;
- **Ground-penetrating radar** – already widely used for locating underground pipes and avalanche victims but requiring a database of radar signatures corresponding to the majority of APMs in use;
- **Infra-red heat radiation detectors** – for locating objects with thermal characteristics significantly different from those of their surroundings;
- **Biosensors** – dogs are already used to detect chemical explosives, so biosensors offer a good potential. Samples taken from a suspected minefield can be analysed in a remote laboratory using gas chromatography, allowing relatively fast identification of mine-free areas;
- **Gamma radiation detectors** – to locate specific explosive chemicals.

But no single approach can currently provide a total solution. Combining several technologies in a single device can reduce false alarms markedly. This requires complex data fusion and decision-making computation. However, the additional cost of all this must be controlled. It will also be necessary to decide how to carry the resulting equipment – should it be airborne, mounted on a vehicle, or hand held.

A simple approach to developing a hand-held device comes from Austrian mine-detection equipment manufacturer Schiebel, which is leading an Esprit project with Swedish associate Celsiustech Electronics (a military electronics company part owned by the Swedish government) and Norwegian Peoples Aid (NPA). The project was scheduled to start in December 1998 and run for two years.

A human mess

Every year, anti-personnel landmines (APMs) claim some 26 000 victims, mainly civilian, in more than 60 countries. The Ottawa Landmine Convention, signed in December 1997 and ratified in September 1998, bans future use of these arms and requires destruction of existing stockpiles. The problem is detection and removal of the many millions of APMs already laid. Buried APMs can remain active for up to 50 years, long after the conflict for which they were laid. And, while an APM costs from $3 to $30 to produce, the cost of neutralisation ranges from $300 to $1000.

As the only major power block that has endorsed the Ottawa Conventions, the EU is taking a leading role in the task of humanitarian mine clearance. The European humanitarian-demining programme is being managed by DG III under Esprit and with the support of the JRC.

Reducing the risks

"We brought in [a non-governmental organisation] to supply the insight necessary to provide a product for field use in the short term," explains Schiebel's marketing director, John Thompson. The approach combines a sensitive metal detector with ground-penetrating radar to reject false alarms. "We wanted to reduce the technological risk," he says. "Effectively we are making the metal detector – already well known in the field – more efficient." The intention is to keep the additional weight below one kilogram.

French company Dassault Electronique has been involved in the GEODE project (ground explosive ordnance detection system) with Dutch, Italian, German and British partners. The objective was to apply data fusion to obtain the best results and the least number of false alarms using a multi-sensor approach with metal detectors, infrared, and ground-penetrating radar.

"We created our own test site – a large open area, controllable and realistic," explains Gilles Guillemard of Dassault. "We cleaned the site on the surface and in depth, calibrated the soil to remove any metal fragments and planted vegetation. We then placed representative samples of mines, small ones next to large ones and with devices such as trip wires, and plotted the positions."

Testing started once the soil had settled, using a test vehicle running alongside the mined strip. The project began in 1998 and will run for 15 or 16 months.

The man in the loop

French defence specialist Thomson-CSF has extensive experience of various sensor techniques and platforms. It has been involved in EC-funded multi-sensor projects for several years, according to project leader François Nivelle. Thomson first took part in the CIMIC project (multi-sensor equipment for landmine detection in civil mine clearance operations) in 1996 with several other European companies, including Dornier and Daimler-Benz Aerospace from Germany and Signaal USFA from the Netherlands.

CIMIC looked at a vehicle-mounted solution combining a variety of techniques, such as ground-penetrating radar, metal detection, thermal infrared, and visible images. The objective was to examine the feasibility of a system based on sensor fusion, which could deliver better performance than that achieved by each sensor

individually, and to develop relevant mine-signature databases.

"We became the project leader for the follow-up project under Esprit in 1998," explains François Nivelle. The DREAM project (data fusion as a remedy against mines) set out to define a multi-sensor fusion system based on the results of CIMIC. "DREAM is designed to be user friendly," he explains. "We are developing algorithms to take into account the man in the loop - information from the sensors has to be fed back to the operator to allow him to take the decision."

At the same time, Thomson is leading the MACADAM project, designed to establish a multi-sensor mine signature database for widespread use. "We carried out extensive tests at the JRC in Ispra in August 1998, using metal detection, ground-penetrating radar, passive radiometry and thermal infrared detection," says François Nivelle. "We put in 80 mines and 40 false alarms – including bullets and pieces of metal." The resulting database is being distributed free of charge; the only condition is participation in a workshop in September 1999 on the use of such data.

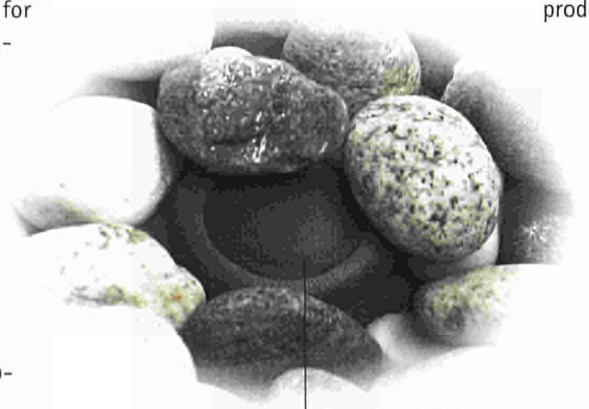
From the Falklands to Africa

The next step is a pilot field project. INFIELD is designed to test a hand-held multi-sensor prototype, with data fusion for easy display to allow fast detection of mines. "We will benchmark the unit at Ispra in April 1999," says François Nivelle. "We will test it in spring 2000 in Angola or Mozambique."

Another partner in INFIELD is research organisation, ERA Technology, from the UK; ERA was also involved in DREAM. ERA has an international reputation in the development and use of ultra-wideband impulse radar.

"Our initial involvement with radar was developments for the Falklands conflict," explains David Daniels. ERA has since carried out extensive investigation into detection of plastic mines with both hand-held and robot-mounted antennae. It is also working on an improved and simplified acoustic man-machine interface.

INFIELD initial results are promising but much more work is required to take account of terrain, environmental conditions, and weather. However, according to Daniels, the key to future development must be potential markets. He sees the need for an international procurement agency for humanitarian-demining equipment. "Industry is currently providing 50% funding for these research projects – so we need guarantees of orders," insists Daniels. "We need a mechanism which provides manufacturers with higher levels of confidence that their investment can be recovered. And we need to have a clear idea of market size to set production costs." ■



Detection of minimal metal mines can be speeded up by a combination of multi-sensor information and sophisticated data-fusion algorithms.

JRC coordination

The Joint Research Centre (JRC) in Ispra, Italy will offer direction and focus for European civilian demining research within the Fifth Framework Programme. "We will coordinate with the end-user community and with national programmes in EU member states," explains Dr Alois Sieber, who is responsible for APM activities at the JRC's Space Applications Institute. "We will be bringing together donors, researchers, industry and users to facilitate the implementation of adapted tools. Our aim is to ensure that effective, appropriate and safe equipment is made available to mine-action programmes as fast as possible and with a long-term commitment."

The JRC is also playing a major global role, co-ordinating demining activities and exchanges of information with the US and the UN. It forms a critical element in the international network of test and evaluation facilities and has organised a series of international conferences and workshops. All developments will be assessed in its test and evaluation facilities at Ispra. These include the European Microwave Signature Laboratory for radar measurements, the European Goniometric Facility for optical and infrared measurements, and the European Electromagnetic Test facilities for sensor characterisation.

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Whistle down the wind

A new anemometer based on a CO_2 laser allows wind turbines to make optimal use of all types of weather conditions. This innovation is an unexpected spin-off from advanced plasma physics research under the nuclear-fusion programme.

The European Union is the world leader in wind energy with more installed capacity than any other region. Over 90% of medium and large turbines installed world-wide are now produced in Europe. And more than half of all turbines come from Denmark.

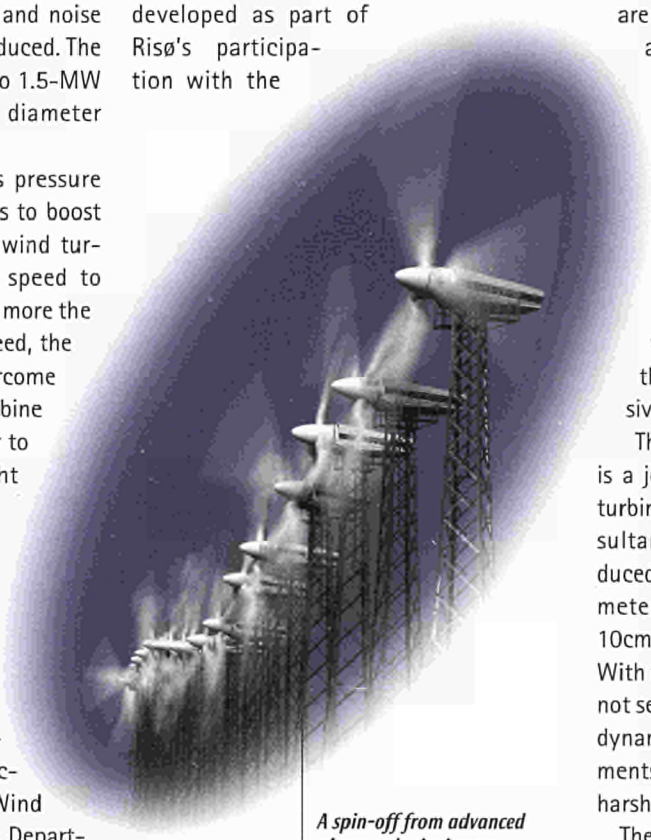
Wind-turbine technology is moving rapidly. Typical wind turbines weigh less than half as much as they did five years ago, average output has quadrupled, and noise emissions have been markedly reduced. The latest wind turbines use 1-MW to 1.5-MW generators and 50-m to 66-m diameter rotors.

However, there is continuous pressure from users for more flexible units to boost efficiency even further. Today's wind turbines demand a specific wind speed to operate at optimal efficiency. The more the wind deviates from that ideal speed, the lower the output. One way to overcome this is to vary the angle of the turbine blades and the speed of the rotor to increase efficiency in both light and strong winds.

Measuring wind speed at the right place

To achieve this, however, it is necessary to know continuously – and preferably in advance – the current wind speed and direction. Tests carried out at the Wind Energy and Atmospheric Physics Department of the Risø National Laboratory in Denmark showed that the best place to measure wind speed is at a point two to three times the diameter of the blades away from the turbine – 150 m to 200 m for modern units – and at the same height as the rotor. This avoids distortion feedback from the motion of the blades and provides sufficient time delay to alter the angle of the turbine blades.

Researchers at Risø showed that such a continuous measurement can be achieved using a laser anemometer based on the Doppler effect. The Department for Optics and Fluid Dynamics had already designed such a tool based on 'light beating' – mixing a light beam with a reference beam to make it possible to measure very small Doppler changes. This advanced measurement technology had been developed as part of Risø's participation with the German Max-Planck-Institute for Plasma Physics in the thermonuclear fusion research programme. It was used to map turbulence in plasma and to determine the level of gaseous stability needed to produce fusion energy.



A spin-off from advanced plasma physics is now helping to optimise the efficiency of wind turbines

A cheap device for every weather

Adapting the CO_2-laser anemometer to wind turbines was the brainchild of two of Risø's researchers: Lars Lading and Sten Frandsen. "Many of the properties of CO_2 lasers are relevant to equipping windmills," explains Mr Lading. First and foremost, the long wavelength means that, compared with visible light anemometers, CO_2 lasers are less affected by fog, rain and snow. In addition, as their wavelength matches the spatial distribution of the reflecting aerosols occurring abundantly in the atmosphere, the optical elements of the laser anemometer do not need to be particularly sophisticated.

"This is important because if you want to see all new windmills fitted with the instrument, it must not make the windmill significantly more expensive," underlines Mr Lading.

The original development of this project is a joint effort involving Risø with wind-turbine manufacturer NEG Micom and consultancy VEA Engineering. Partners produced a prototype of the CO_2 laser anemometer that could be housed in a casing 10cm to 15cm in diameter, and 50 cm long. With these dimensions, the instrument does not seriously affect the wind turbine's aerodynamic properties or structural requirements yet is robust enough to withstand harsh conditions.

The two companies are also included in a patent application for the laser system. The Department of Optics and Fluid Dynamics helped fund the preliminary project; steps are now being taken to continue the project under the auspices of the EU. ■

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