BR-184 (IX)
January 2003

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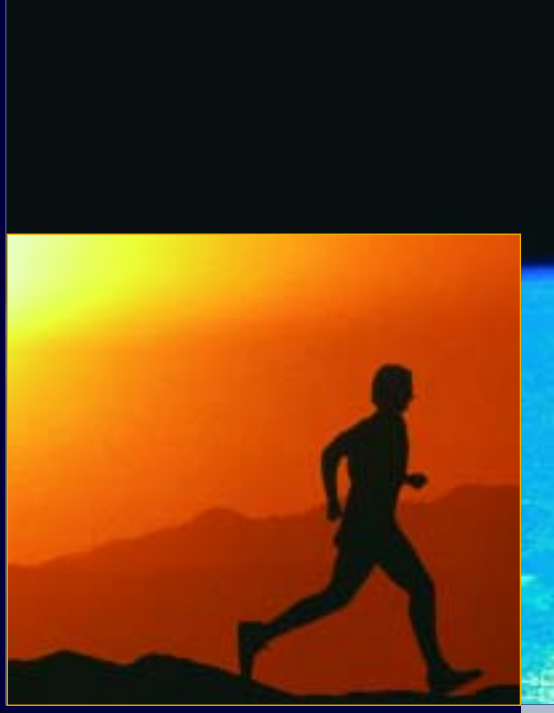
MEDICINE II

Technology Transfer Programme

Technology Transfer Programme



What do medical health care,disease and satellites have in common? This brochure will help you find out, and tell you just how the European space industry is having an increasing impact on medicine in general.

Several of the technologies used in the medical field come from systems that were developed for applications in space. I hope this brochure will give you an insight into how advanced European space technologies are being applied to our precious health, not only to take care of it but also to restore it, as much as possible.

Many innovative non-space products and services that will benefit society are now being introduced as a result of technological spin-offs from the space industry, and it is worth remembering that medicine is not the only sector to take advantage of the new technologies developed by European space companies.

I hope this brochure will enable you to discover the new and unexpected ways in which space activities improve our daily lives.

Pierre Brisson
Head of the Technology Transfer and Promotion Office

Keeping in good physical shape wherever we are is one of our major concerns. Medical space research has pioneered many methods and devices for monitoring and keeping astronauts healthy. Some of these technologies are already being used on Earth in medical health care, but there are plenty of other space technologies which are also finding unforeseen uses in medical and health care. For instance, scientists using bio-imaging for diagnosing disease and research have benefited from sharing much common sensing and imaging technology with space researchers and vice-versa.

Advanced data-processing methods have also been adapted to help analyse the increasing amounts of information that biological researchers have to handle.

FROM SPACE TO BABIES: MAMAGOOSE PYJAMAS

Sudden Infant Death Syndrome (SIDS), commonly known as cot death, is the sudden and unexpected death of a baby for no obvious reason. In the United Kingdom, cot death affects around four out of every 10 000 healthy babies, 86% of whom are less than six months old. In the United States more than 2500 babies die each year within the first 12 months of life from symptoms attributable to SIDS.

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A new type of baby pyjamas, developed by the Belgian company Verhaert Design and Development and the Free University of Brussels (ULB) and based on space technologies, could help in preventing SIDS. The pyjamas, called Mamagoose, draw on technology used in two space applications: the analogue biomechanics recorder experiment and the respiratory inductive plethysmograph suit. This transfer of technology designed for space to Earth application is an initiative of ESA's Technology Transfer Programme. The Mamagoose project is also partially financed by the German Space Agency and IWT, the Belgian institute for the promotion of scientific and technological research in industry.

The Mamagoose pyjamas have five special sensors positioned over the chest and stomach: three to monitor the infant's heart beat and two to monitor respiration. This double sensor system guarantees a high level of measuring precision. The special sensors are actually built into the cloth and have no direct contact with the body, thus creating no discomfort for the baby.

Mamagoose pyjamas are made of two parts: the first, which comes into direct contact with the baby, can be machine-washed and the second, which contains the sensor system, can be washed by hand. The pyjamas come in three sizes, are made of non-allergic material and have been especially designed to keep the sensors in place during use.

The control unit has an alarm system, which is connected to the pyjamas and continuously monitors and processes the signals received from the five sensors. It is programmed with an alarm algorithm, which scans the respiration pattern to detect unexpected and possibly dangerous situations. If found, an alarm system is activated. In addition, the selective memory records data for a certain period before and after the alarm to assist doctors in making a diagnosis.

Mamagoose prototypes have been tested on many babies in different hospitals, environments and conditions. These include babies of various weights and sizes, when they are in different 'moods' such as calm, nervous or upset, and when they are sleeping in different positions. To date, the results have been extremely promising. Verhaert will be responsible for producing Mamagoose once the tests currently being carried out in Germany have been completed while the biomedical physics laboratory of ULB will be responsible for improving the processing algorithm and for providing paediatricians with feedback on the research results

ALLOYS FOR WISDOM TEETH

What about using tough space materials that return to their original shape to re-position teeth, mend bones and even break rocks? Shape memory alloys (SMAs) are such extraordinary materials. Like an elastic band, they can be stretched and deformed and then return to their original shape. Even more remarkably, they can 'remember' a shape that has been locked into them - such that if bent into a new shape, they will return to their original form when warmed up or cooled, often exerting considerable force in the process.

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The European space programme developed SMAs for use as lightweight, temperature controlled actuators. The unique features of SMAs were, however, showing great promise in a number of other fields, and especially as medical devices. In the 1990s in the UK, when Brunel University's Institute of Bioengineering was experimenting with SMAs, one of their researchers, Tony Anson, realised they could be used in the repair of broken bones. Staples, bent from SMA wire, are placed across the fracture in pre-drilled holes. Body heat then causes the legs of the staple to draw together, both closing and supporting the fracture during healing.

In 1994 Tony set up his company Anson Medical and two years later the company began working with OrTech, a small dental engineering consultancy in Norway, and the Danish Technological Institute, to create an orthodontic spring to control the movement of teeth. About a quarter of all children need orthodontic treatment and many more adults seek help to improve the cosmetic appearance of their teeth. SMAs - which can be stretched much more than conventional springs - allow constant gentle forces to be applied to teeth in a precise way. As well as being more comfortable for the patient, the teeth move two and a half times faster to their pre-destined positions than in previous treatments. Anson Medical subsequently developed a range of other applications and in 2001 was acquired by a major UK company, ensuring the continued exploitation of SMAs in the medical field.

SPACE PUMPS HELP PANDAS REPRODUCE

In perhaps one of the strangest examples of the unforeseen uses of space technology, a miniature pump developed for space by Brunel Institute of Bioengineering in the UK, has been used by vets to help to improve the love life of a female giant panda – unfortunately with inconclusive results

Several years ago, a planned ESA microbiological space mission threw up a requirement for a simple, miniature low-power pump to transfer liquid nutrients around a small orbiting microbiological laboratory, which was designed to study plant growth in space.

Brunel produced a prototype for such a pump, which, at the time, was probably the smallest of its type in the world. Coincidentally, they heard of a problem confronting scientists in the USA who were seeking to stem the decline in the world's population of giant pandas. One of the contributing factors was that the female panda comes into season only once in 12 months – severely limiting the number of mating opportunities. The scientists had determined that, if they could introduce hormones more frequently into the panda's body, then mating should be possible on demand.

What was needed was a pump, timer and reservoir small enough to be implanted in the panda's back, providing unobtrusive, regular supplies of hormones, which could be made to coincide with the introduction of a male partner. The Brunel space pump fitted the bill exactly and was eventually implanted in a female panda in Washington Zoo. The pump worked perfectly, but the longed for happy event never materialised proving that, although space spin-off knows no bounds in matters of the heart, technology cannot always provide the answer!

KEEPING FIT WITH A YOYO

Keeping fit in the weightless environment of space requires special kinds of exercise programmes and equipment. After all, what use are dumb-bells if they just float around of their own accord? In space, everyone can manoeuvre objects they would have no chance of lifting on Earth, but the down side of this is that the body does not get the exercise it needs to keep in top condition. Being in space is an extremely demanding activity, and a huge amount of attention is paid to the well-being and fitness of astronauts. As missions get longer and longer this becomes even more important, and engineers and doctors are working together to design equipment and exercise programmes specially suited to the specific needs of space travel and weightlessness.

YoYo Technology based in Stockholm, Sweden has developed a machine designed to meet these unusual requirements. With support from the Karolinska Institute, the Swedish Space Corporation and the Swedish National Space Board, YoYo developed equipment that uses the inertia of flywheels to provide

resistance. The Fly-Wheel Resistance Exerciser (FWRE) differs from the normal equipment found in gyms because it provides 'two-way' resistance. The user is required to pull the cord from a flywheel and at the full stroke the flywheel begins to wind the cord back in. The user has then to resist this by pulling back on the cord. In effect, this is the same principle as that behind the yoyo - the child's toy which has certainly stood the test of time.

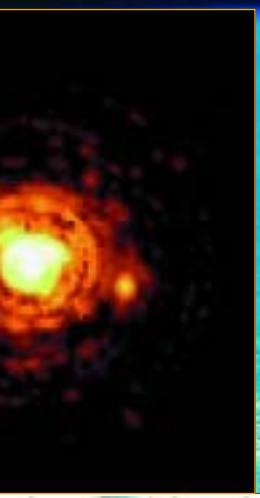
The advantage of this system is that the load can be easily varied by changing the flywheel or altering its diameter. Users can also determine the amount of 'impact' in their training. Unusually, astronauts in space are encouraged to do high-impact exercise since it maximises body strength while also minimising bone loss.

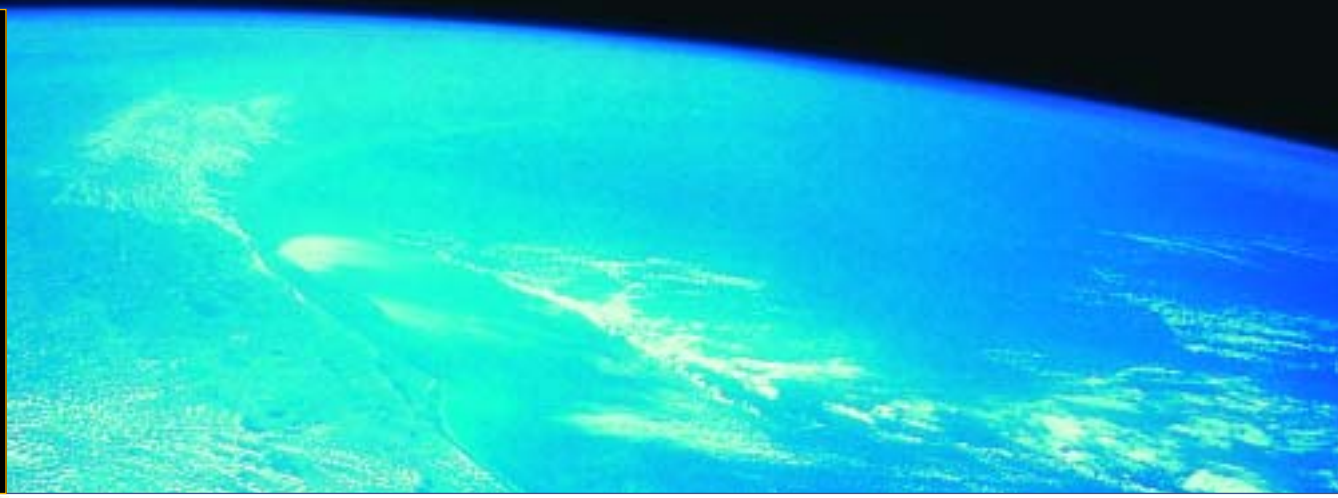
Having successfully designed equipment to meet the needs of the space industry, YoYo Technology is now turning its attention to terrestrial applications such as in sports training and medical rehabilitation. For instance, the equipment is being used by the Swedish Olympic athletics team. It is also being employed in orthopaedics to aid the recovery of stroke patients, and it is proving particularly useful in re-establishing nerve connections in damaged muscles. A variant of the equipment is also being developed for use in home gyms, a market that is worth many millions of euros worldwide.

HUMAN WASTE MANAGEMENT BENEFITS FROM SPACE RESEARCH

In the course of work carried out for ESA, considerable know-how and expertise has been gathered at an Austrian aerospace company in developing waste treatment technologies to collect, compact and store human waste under exacting conditions.

Waste treatment operations for space applications have to fulfil the most stringent hygiene requirements, since microbial contamination in a closed environment inhabited by man may cause serious health problems to the crew and may jeopardize their mission. The technology is based on the simple principle of using a non-returnable faecal container, which contains an integrated welding facility, which automatically seals the container after use. The sealed container can then be handled with minimal risk for analysis and disposal.





Based on this design for space use, the company has developed a clean-room toilet to meet the needs of the bone marrow transplant unit of an Austrian Hospital. Patients who have to undergo this type of transplantation are vulnerable to many kinds of infections, as the immune system has been diliberately weakened to enable the transplantation treatment. Patients are accommodated in clean rooms with laminar airflow and the hygienic requirements for a toilet in this environment must be stringent and similar to those in manned space flight. The main purpose of the development was to provide a toilet facility next to the bed of the transplant patient to avoid the obvious disadvantage of bedpans in this environment. The toilet is intended to be used until the patient's immune system has recovered and also helps to protect nursing staff from waste containing toxic chemicals or from becoming contaminated with infectious germs.

The technology is not restricted to use in hospital clean rooms, but can provide new solutions to the waste handling problem in other areas where high labour costs or scarce labour resources make traditional technologies increasingly unattractive or where new disposal systems are required for environmental protection.

GETTING TO THE HEART OF THE PROBLEM

Most people don't realise that space isn't actually empty, but instead is full of dangerous radiation which can damage electronic equipment on spacecraft. Consequently space vehicles carry instruments to measure and record the radiation around them and the damage it does to onboard electronics.

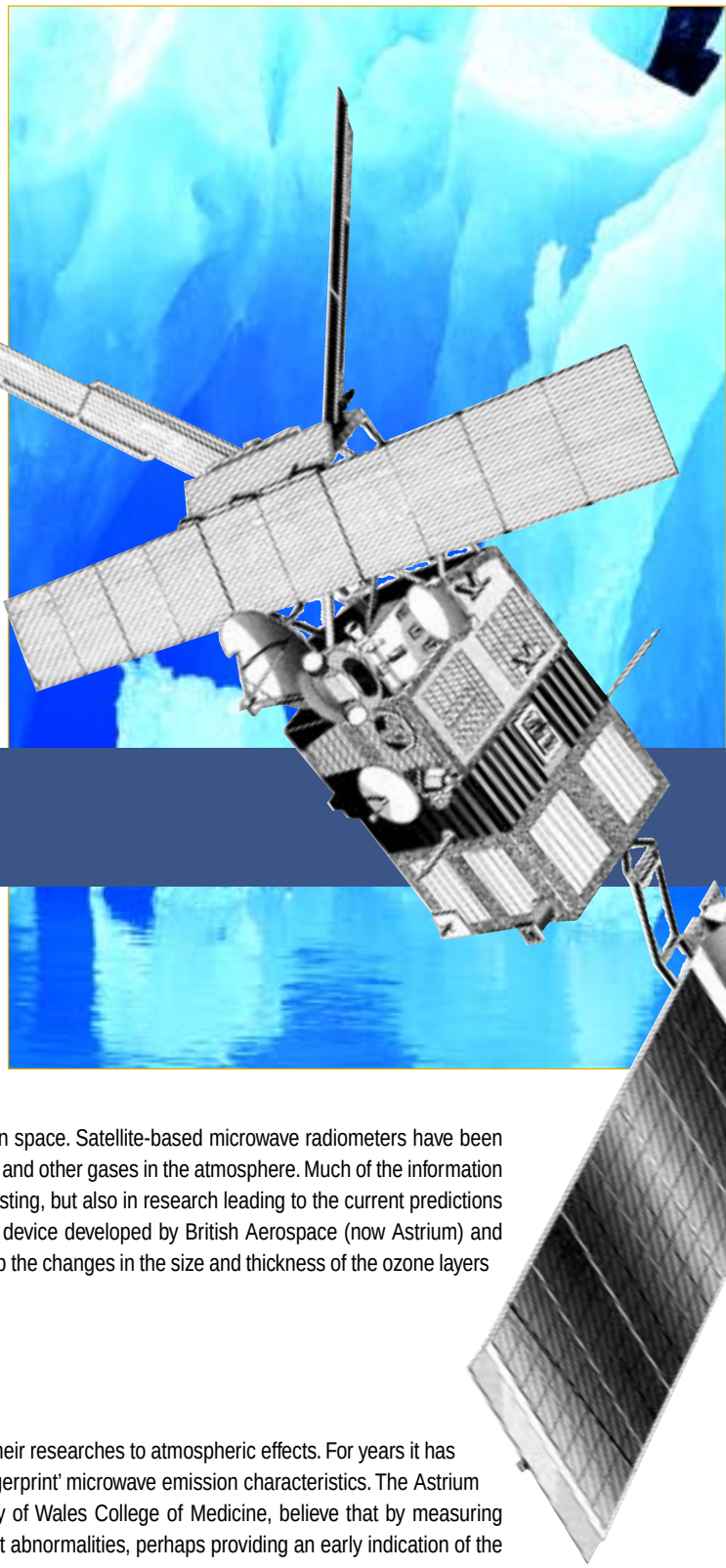
One such device is a silicon chip called a RADFET (radiation-sensitive field-effect transistor) developed in the late 1970s by a small UK company – REM (Oxford) Ltd. This device monitors the cumulative dose of radiation and has been incorporated into spacecraft such as Metosat-3 and the Hubble Space Telescope.

The radiation-sensitive chip not only records the amount of radiation received, but can also convert it into a radio signal. The radiation dose can thus be communicated to mission controllers. This key advantage – remote reading – offers the potential for applications on Earth where remote sensing is necessary, such as nuclear safety and medicine. With the aim of exploiting this development potential, REM and a number of other groups are working to identify commercial applications for the device. The sensing element is also cheap to make and can easily be mass-produced. Furthermore, because the sensor is small, it was quickly realised that it could be used as a dosimeter for monitoring radiotherapy used in treating cancer and heart disease. Previously radiation monitors were expensive, unable to record in real-time, and too large to be used inside the body.

At the University of New Mexico, an oncologist has placed the small chip in a cancer-therapy catheter within a breast cancer, and at Harvard Medical School RADFET sensors were inserted inside tumours in mice, prior to radiation treatment, to record the dose received. The results encouraged REM to pursue further medical applications and, working with the Italian Institute for Cancer Research (IST), the company explored a new use for radiation and dosimeters in treating blocked arteries.

Sometimes, an artery can be unblocked by inserting a 'balloon catheter' and inflating it in order to expand the blood

vessels. Unfortunately the blockage can re-occur, but recent research has shown that this can be prevented by irradiation, ideally with beta rays. The process, called endovascular brachytherapy, involves inserting a radioactive source into the blood vessel via a catheter. One problem, however, is that the radiation dose must be monitored carefully to prevent damaging the surrounding tissue. RADFET offers an effective way of doing this and is cheap enough to be thrown away after use – so this small space-derived device could develop into an important tool in ensuring the efficacy of this treatment for thousands of potential patients around the world.



MICROWAVE MAGIC

We are surrounded by microwaves – not only the high-power, well-protected variety that heat our microwave ovens, but also the low-power waves emitted by the millions of mobile phones now in circulation. Microwaves also have other, more scientific uses. Like other forms of electromagnetic radiation, they are absorbed and emitted by various materials in a uniquely characteristic way. The resulting microwave spectrum allows scientists and engineers to detect and analyse these materials, often remotely.

One of the first applications of microwave spectroscopy was in space. Satellite-based microwave radiometers have been used for some time to measure the distribution of water vapour and other gases in the atmosphere. Much of the information gleaned has been used not only for short-term weather forecasting, but also in research leading to the current predictions on global warming and climate change. Indeed, a microwave device developed by British Aerospace (now Astrium) and Rutherford Appleton Laboratories in the UK was the first to map the changes in the size and thickness of the ozone layers above the North and South Poles.

DIAGNOSING DISEASE

Astrium and RAL scientists have not been content to confine their researches to atmospheric effects. For years it has been speculated that individual living cells have their own 'fingerprint' microwave emission characteristics. The Astrium and RAL team, supported by researchers from the University of Wales College of Medicine, believe that by measuring changes in characteristic emissions they may be able to detect abnormalities, perhaps providing an early indication of the

onset of disease. This possibility was foreseen by the Star Trek doctor 'Bones' whose hand-held microwave wand gave an instant diagnosis for anyone it was passed over! The team does not envisage such a straightforward solution; however, the equipment developed for Earth observation will provide an excellent starting point.

With help from ESA and venture capitalists, the RAL team has set up a spin-off company to seek commercial applications. These are also not only connected with disease diagnosis; as the team gains a greater understanding of the interaction of microwaves with living cells, it may be possible to use microwaves to influence other biological processes such as those used in making food and drink products.

SATELLITE IMAGING HELPS PREVENT STROKES

The past 20 years have seen a vast increase in the number of orbiting satellites dedicated to producing high-quality close-up images of the Earth's surface. Satellite imagery is now routinely used for such diverse activities as iceberg tracking, checking on supertankers illegally discharging oil, and mapping deforestation. There are now available over the Internet large libraries of images down to a resolution of one metre showing individual buildings and roads. These can be of immense value to town and country planners, gas, electricity and water utility companies, and also to road planners collecting data on traffic flows.

Some of these applications require great accuracy from the on-board satellite imaging systems. The Landsat satellites, for instance, had to produce precise referenced maps as they were used to observe and record the change in use of agricultural land – often of considerable economic significance for farmers.

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Some of the sophisticated software required was developed by ACS of Italy. The software provided real-time imaging and a geometrical-correction capability necessary to provide the high degree of positional referencing required, and that company has since applied the same techniques to meet more down-to-earth imaging needs. Now doctors can keep track of patients' blood circulation using high-speed imaging software designed for Earth observation.

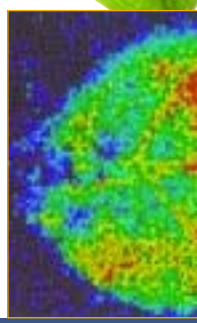
For some time, doctors have seen the potential for using scanning techniques to measure the speed of blood flow through the major veins and arteries. The problem has been to convert the mass of scanner data received into useful diagnostic information. Taking advantage of the software's ability to process imaging data very rapidly, doctors may now be able to produce images of the blood flow in real time. This will greatly simplify the task of detecting restrictions in blood vessels and providing patients with an early-warning system for strokes and other circulatory diseases.

GLOW WORMS LIGHT THE WAY

The world has been amazed by the breathtaking images from the Hubble Space Telescope (HST) of galaxies billions of light years away. Like all modern optical instruments used by astronomers, one of the HST instruments exploits detectors called charge-coupled devices, or CCDs. These are silicon chips consisting of arrays of light-sensitive 'pixels', which convert impinging light into an electric charge that can then be used to generate an image. Today, CCDs are found everywhere – in your digital or video camera, for example, or the office photocopier.

These CCDs are controlled by special software that ESA went on to license to a UK company specialising in making CCD cameras for biomedical applications. The company was supporting the work of medical researchers in the UK who have for some time been using some novel techniques for 'observing' the workings of living cells.

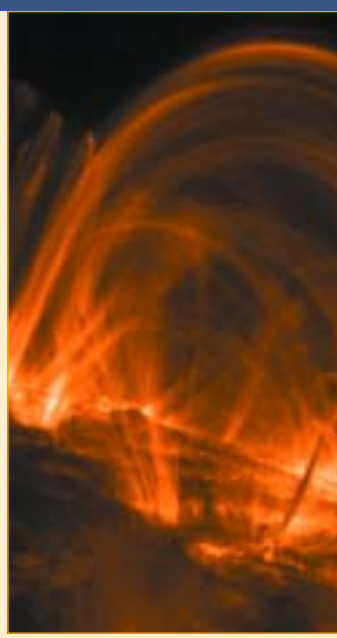
Tony Campbell, a Professor at the University of Wales' College of Medicine, is one such researcher. He inserts a bioluminescent protein extracted from glow worms into a living cell so that it illuminates the cell's activity. The luminescent molecules attach themselves to calcium ions (thought to be the cell's 'messengers'), which can then be followed visually as they move around the cell. Using the detector, one can see cells responding in real time and, in an early experiment, Professor Campbell could actually watch the response of a seedling being touched by an ice cube! This ability to observe the innermost workings of a cell is important in understanding and controlling disease, and this has been the main object of Campbell's work.



The story does not stop, however, with CCDs – the technology is moving on. A new type of light detector called a superconducting tunnel junction (STJ) diode is being developed which can also register the colour of the photons – information of great interest to astronomers and biomedical researchers alike. Indeed, Campbell is now developing a range

of genetically engineered 'rainbow' proteins, programmed to change colour when they bind with a particular chemical in a living cell.

This research has exciting implications for our future health. For example, a potentially cancerous cell will change from red to green, or from red to blue, and the next generation of cameras will be able to record this, providing scientists with valuable information in the fight against that deadly disease.



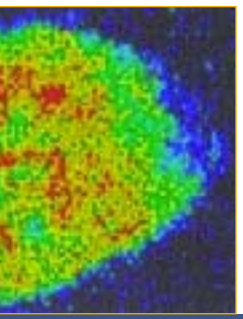
MONITORING COSMIC RAYS IN CONCORDE

Radiation is not something air travellers normally worry about, but novel sensor technology monitoring radiation in spacecraft is ensuring that frequent high flyers don't get an unexpected dose of cosmic rays.

Spacecraft are exposed to significant amounts of radiation - some of it from the solar wind (the stream of energetic particles from the Sun) and some of it very high energy cosmic rays from deep space. This radiation can damage a satellite's onboard electronic systems if unprotected. In extreme circumstances this can cause the spacecraft's computers to crash, putting both the spacecraft and its crew in danger. The radiation also poses health risks for astronauts, particularly those on long-term missions. Spacecraft engineers and designers are therefore keen to find out more about the effects of radiation on spacecraft and astronauts.

In the early 1990s two ambitious experiments were launched on board the NASA Space Shuttle and the UK's UoSAT scientific satellite to measure the amount of radiation the two spacecraft were exposed to during their time in space. The two experiments, called CREAM (Cosmic Radiation Effects and Activation Monitor) and CREDO (Cosmic Radiation Effects and DOsimetry), were designed by the UK's Defence Evaluation and Research Agency (DERA) and AEA Technology, along with several other research organisations.

Following the experiments' success, people soon realised that the technologies developed could be used for measuring cosmic rays nearer to the ground. Whilst the Earth's atmosphere shields people on the ground from cosmic radiation, high-flying aircraft such as Concorde are, like spacecraft, exposed to it. Although the degree of exposure is very small at any one moment, it does build up over time, and there are concerns about the effects on the health of both crew and frequent flyers. To help scientists measure exactly how much radiation the aircraft and people on board are exposed to, a replica of the CREAM experiment was installed on a British Airways' Concorde aircraft.



It was found that the actual radiation levels at high latitudes in the Northern Hemisphere (where most of these aircraft fly) were less than scientists had predicted. The Earth's magnetic field appears to have a much greater impact in controlling the amount of cosmic rays penetrating the atmosphere at these latitudes.

The CREAM experiment on Concorde also confirmed the findings from earlier space experiments in that the amount of cosmic radiation increases markedly during periodic increases in solar activity (for example, solar flares and sun spots). Partly in response to this experiment, several organisations are now investigating the possibility of establishing an early-warning system for airlines to advise them of an impending surge in solar activity. The intention is that airlines would use this information to re-route their aircraft to higher latitudes, and to advise passengers who are more susceptible to such radiation (such as pregnant women) not to travel.

Benefits for our daily lives: The ESA Technology Transfer Programme

Over the past 35 years, the European space industry has gained considerable expertise in building, launching, controlling and communicating with satellites. From this long experience of how to overcome the hazards and problems created by such a hostile environment, many valuable new technologies, products and procedures have been developed. Today, this expertise is improving our daily lives by providing many innovative solutions for products and services on Earth.

Groundbreaking European space technologies are becoming increasingly more available for development and licensing to non-space industry through the process of technology transfer. The ESA Technology Transfer Programme has already achieved over 150 successful transfers or spin-offs from space to non-space sectors.

This success is reflected by the fact that since 1991 technology transfer has generated more than 20 million euros in turnover for European space companies and 120 million euros for the non-space industries involved. Already 2,500 jobs and 25 new companies have been created.

The ESA Technology Transfer Programme is carried out by a network of technology brokers across Europe and Canada. Their job is to identify technologies with potential for non-space applications on one side, and on the other side to detect the non-space technology needs. Subsequently, they market the technology and provide assistance in the transfer process.

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To learn more about ESA's Technology Transfer Programme please contact:

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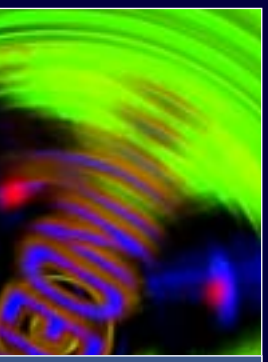

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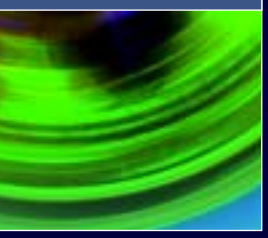

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Published by
ESA Publications Division
ESTEC, PO Box 299
2200 AG Noordwijk
The Netherlands

Editor
Bruce Battrick

Design & Layout
Leigh Edwards

ISSN No.: 0250-1589
ISBN No.: 92-9092-722-4