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esa

SAFETY & SECURITY

Technology Transfer Programme

Technology Transfer Programme

What do safety and security and satellites have in common? This brochure will help you find out, and tell you just how the European space industry is having a growing impact on our safety on a daily basis.

Several of the technologies used for security 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 help prevent accidents and keep us safe and secure.

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 safety 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 are improving our daily lives.

Pierre Brisson
Head of the Technology Transfer and Promotion Office

Coping with the hostile environment of space is a huge task and astronauts and spacecraft both face lots of potential dangers from extremes of heat and cold, radiation, vibration, etc. It is therefore hardly surprising that safety measures are one of the natural spin-offs of space exploration. Through the ESA Technology Transfer Programme, important progress has been made in the security domain through the adaptation of a wide range of space-derived protection methods and tools. From the protection of individuals, to automotive and aeroplane safety equipment, at home and in the work place, many space technologies have found very useful safety- and security-related applications here on Earth.

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SCREENING OUT VANDALS

Theft from lorries and haulage containers is a growing problem throughout Europe and those with sides made of fabric are particularly vulnerable to attack. Cargo containers spend a lot of time unattended in loading or storage depots and their tarpaulin covers, while light and convenient to use, offer little protection against the knives of vandals and thieves.

By 1996, so serious had this problem become that three companies, a French manufacturer of haulage containers, a Belgian plastics and composites company and a large Belgian rail/road haulier joined forces with CRIF, a Belgian collective industrial research centre, as the main focus of research, to develop a new protection system for containers.

The work was supported under the European Union's CRAFT scheme and initial studies pointed towards the development of a better material for fabric screens, which would retain the advantages of lightness, flexibility and ease of cleaning, whilst also offering great strength and resistance to attack. But the question was where to find such a material?

THE FRENCH CONNECTION

As part of its normal work, the ESA technology broker network surveys non-space companies to see what kinds of technology they might need. It was through this mechanism that ESA's Belgian network partner Creaction circulated the requirement for a vandal-resistant textile. By good fortune, a French company Societé Ariegeoise de Bonneterie, following

the success of its flame-proof textiles used on the Ariane rockets, had modified its knitting technique to create from steel wire a flexible fabric which was extremely difficult to cut and well-suited to the application. A newspaper article about this new material was spotted by Novespace, ESA's French technology broker at the time, and the connection was made.

Parcouri, a consortium of eight European companies that includes a Dutch multinational producer of vehicle covers and a French SME specialising in coach building and kit fixing systems, is now developing a vandal-resistant alternative to the standard tarpaulins currently in use. Within an existing global market of 120 000 units a year, current predictions for the new material show a healthy potential initial market of 7000 units annually.

SPACE FASHIONS ARE COOL

Clothing that will keep its wearer cool in even the hottest environment will come as a great relief to many workers. Firemen and motorcyclists in their heavy protective clothing, bakers and foundry men all suffer from excess heat. Now Zodiac, the Spanish company that co-designed the European space-suit, has joined forces with a Belgian university and two other partners to develop air-conditioned clothing for use on Earth, thus contributing to safety.

Their system, which is worn as an undergarment, is light in weight and blows cooled air over the wearer's skin, taking advantage of the body's natural perspiration mechanism. The cooling system, which is based on the Peltier effect and requires few moving parts, is powered by rechargeable batteries to allow full mobility. The undergarment may be worn on its own or with full protective gear, and is currently being assessed by the London Police for use under bullet-proof vests.

For more extreme environments, a full suit can be provided in which air-cooling may be supplemented by liquid refrigerant pumped through a network of tubes within the suit. Drawing upon its space-suit technology, Zodiac has also incorporated breathing systems that provide the highest levels of protection, while the use of battery packs ensures independence and freedom of movement for the wearer.

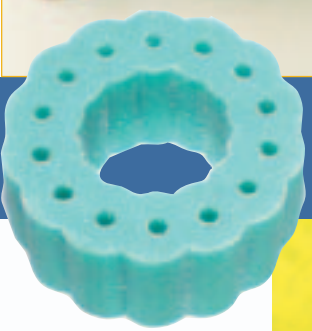
Advanced European space suit concept (EVA suit 2000)

MAKING TRAVEL SAFER

Most of us have to travel, whether on business or for pleasure or just in our everyday activities, and travelling as safely as possible is an important criterion for transport manufacturers who are continually looking for ways to improve reliability and safety. Technology originally designed for space applications is contributing to such developments, and two French examples show how this is working in practice.

CARBON BRAKES

Composite materials made from a carbon matrix reinforced with long carbon fibres can withstand high temperatures, and are very resistant to wear. These materials were originally developed for use in the extreme conditions found in the engine nozzles of Europe's Ariane rocket. The developers realised that brakes made from such composites were more reliable, produced less vibration, and caused less pollution than the traditional braking systems fitted to aircraft and road vehicles. Messier-Bugatti, based in France, produced a novel carbon braking system called Sepcarb® for use on aircraft such as the Airbus and now supplies one-third of the world market for carbon-composite brakes for commercial aircraft with more than 100 seats (over 145 airlines have now chosen Sepcarb® carbon brakes for more than 1600 aircraft). Similar systems have also been employed on Formula-1 racing cars, road vehicles and passenger trains.



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FASTER INFLATING AIRBAGS

Another important safety feature - the airbag - has contributed a great deal to safer car travel in recent years, saving many lives and helping to prevent serious injury in collisions. Today, it is considered to be one of the most important safety devices since the seat belt was first introduced in the 1960s. When an airbag inflates, there is essentially a controlled explosion occurring inside your car! The typical standard device is housed in the centre of the steering wheel along with the inflator. An igniter activates compressed gas capsules and these fill the bag with an inert gas when an impact of above a certain force is sensed. The whole inflation process occurs within a split second and the bag is completely deployed in less than a second – quickly enough to restrain the occupant.

As most new cars employ such safety devices, the market for the pyrotechnic charges is large. The French company SNPE Propulsion is using its knowledge in the field of solid propulsion for ballistic missiles and space launchers to design and develop the pyrotechnic charges used in airbag gas generators and seat-belt tighteners. SNPE Propulsion estimates that its products are used in one in four of the safety devices fitted to new cars each year.

PRESSURE-SENSITIVE PADS

To help in the construction and maintenance of the International Space Station, the Canadian Space Agency has been coordinating the development of the 'Special-Purpose Dextrous Manipulator' (SPDM). This is a two-handed robot which is essentially an extension of the astronauts' own limbs. Until recently, these augmented limbs lacked one critical feature - a sense of touch. Without a sense of touch, machines can easily accidentally bump into or knock over other objects. In space, this can obviously have drastic consequences. Although automated vision systems have been under intensive development for several years, tactile sensing technologies are rare and relatively primitive.

Recognising this challenge, Canadian company Canpolar East developed Kinotex. This is a novel sensor that emulates human touch and can be applied like a skin or sleeve to cover entire robotic limbs. Described as a 'deformable integrating cavity', the sensor consists of a sheet or block of polymer foam with an opto-electronic transducer embedded in it. When the foam is deformed, its optical properties are altered, generating a proportional signal in the transducer. Normally arranged in arrays, these sensors can detect and interpret contact at many points over the surface of the machine. Because they use light to detect change, Kinotex sensors can be very small and are immune to interference from sources such as electromagnetic radiation. They are also very responsive, sensing minute amounts of pressure and reacting extremely quickly to change.

Many industries are implementing Kinotex products. For example, automotive companies have acquired the rights to develop pressure-sensitive car seats that help increase safety. Kinotex sensors are also being considered for incorporation into energy-absorbing bumpers for determining the severity of crashes. So, thanks to the sense of touch developed for robots in space, we may all be able to travel much more safely in our vehicles!

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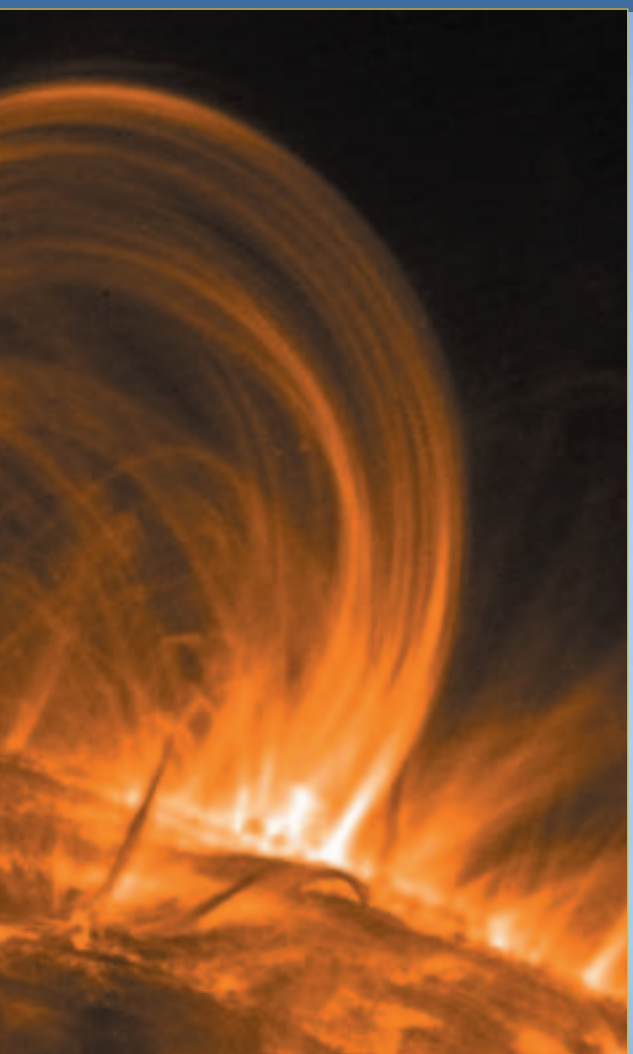
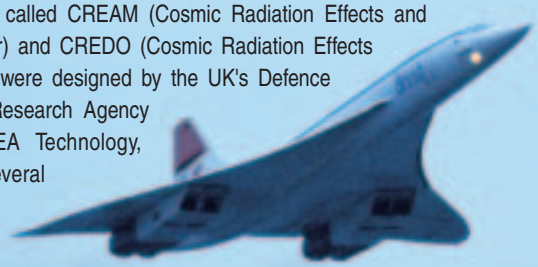


MONITORING COSMIC RAYS IN CONCORDE

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 space vehicle 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 subsequently developed could also 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, like spacecraft, are 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 long-term effects on the health of both aircrew and frequent flyers.

To help scientists measure exactly how much radiation the aircraft and people on board were exposed to, a replica of the CREAM experiment was installed on a British Airways Concorde. 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 spurts 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 impending surges in solar activity. The intention is that airlines would use this information to re-route their aircraft to higher latitudes, and be in a better position to advise passengers who are more susceptible to such radiation (such as pregnant women) when not to travel.

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ROCKET TEXTILES THAT TAKE THE HEAT

Courtesy of Tourism Toronto

A woven fabric that will withstand flames and provide protection against extreme heat seems an unlikely outcome from space technology, but these are precisely the properties needed by designers of rocket motors to defend sensitive equipment from the exhaust flames.

In 1990, Aérospatiale and SEP (Societé Europeene de Propulsion) approached a family-owned textile company in Montferrier, France for help in developing flame-proof materials for use in rockets. SAB (Societé Ariegeoise de Bonneterie) drew upon its 40-plus years of experience in textile knitting and coating to produce Flamebreak, a unique textile that both stops the advance of fire and insulates against the transmission of heat.

Using a special knitting technique, Kevlar and Preox fibres are combined to create an optical filter capable of blocking 90% of infrared radiation over a wide temperature range. By layering the material, almost all heat transfer can be eliminated. For the Ariane rocket, Flamebreak is impregnated with a special Aérospatiale silicon coating to produce a laminated material with excellent flame-resistance.

The remarkable properties of Flamebreak are perhaps best illustrated by its application at the Centre d'Etudes Atomiques de Cadarache (CEA) in France. During high-temperature studies of the cooling system of a nuclear reactor core, Flamebreak protected employees from 2100-2500°C heat and dripping molten metal, while transparent screens, also made from Flamebreak, permitted researchers to observe their tests at close quarters.

In a field with few competitors, commercial applications for Flamebreak are widespread. Companies in the metal- and glass-working industries, such as Pechiney SA and St Gobain SA, have used the remarkable insulating properties of Flamebreak to good effect in shielding their production workers, while the excellent performance of Flamebreak as a fire-retardant has been incorporated into upholstered seats for vehicles and public buildings, most notably in the Toronto Skydome.

FIRE-PROOFING THE CHANNEL TUNNEL

The launch phase of the Ariane rocket generates extremely high local temperatures and this has led to the development, by Aérospatiale, of a family of fireproofing materials known as Aerocoat, which protect sensitive equipment in the rocket and ensure that it continues to function. Aérospatiale has now, through licence collaboration with APS, made the technology available for any appropriate ground-based use where excellent thermal protection is a necessity. Already, several applications have been identified for Aerocoat. These include applications by the French railway company SNCF for the protection of sensitive equipment in the trains used for the Channel Tunnel link, and by Gaz de France, for the protection of lead gas pipes in cellars and other locations.

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SAFER MINING

Mining operations have proved to be an extremely fertile field for space technologies and robotics. One of the most promising projects involves a Belgian company called Space Applications Services (SAS). In a contract for ESA, SAS developed expertise in the Man/Machine Interface (MMI) field and created a suite of software programs (called FAMOUS) to control the preparation, planning and execution of robotic operations. ESA's Technology Transfer Programme, through its Harsh Environment Initiative (HEI), has been a key factor in transferring this technology to improve the productivity and safety of mining operations.

Although, mining machines can be controlled remotely by operators on the surface, current methods have a number of drawbacks. For example, incorrect information and delays in receiving information can lead to collisions. It then becomes necessary to convert from the concept of direct control by the operator to one of operator supervision of multiple machines performing different tasks in the mine. In a move towards this next generation of automated mining, R&D activities are underway to automate different machine sub-tasks, such as loading and dumping, and navigation. In a series of projects based on Sensori-Motor Augmented Reality for Tele-robotics (SMART), space-based technologies such as MMI, ground-penetrating radar, loss-less data and image compression, and space robotics, to name a few, will be integrated to control individual machines. A supervisory system that can simulate particular events will also be developed, by C-CORE in Canada. This will lead to more efficient deployment of machinery by optimising the use of shared resources such as tunnel intersections and rock-dumping sites.

RADAR SYSTEM BREAKS NEW GROUND

Ground-penetrating radar developed for space exploration offers new hope in preventing mining accidents and detecting landmines. Radars play an increasing part in everyday life. Most of us are aware of their original purpose in detecting aircraft or ships, and some of us have suffered the consequences of their role in catching speeding motorists, but not many of us would associate radar with detecting objects underground.

As computer processing power increases and becomes cheaper, ever more complex signal processing can be applied to radar signals and, by careful choice of frequencies, it is now possible to use portable radars to penetrate the ground and produce images of hidden structures and objects. Ginger, an ESA technology project, set out to develop a ground-penetrating radar in support of a proposed programme to explore the Moon. Now, the same technology is showing great promise in a new life-saving role.

Deep underground, liners and supports are often used to maintain the integrity of tunnels. Unfortunately, in some areas where the rock is hard, fine cracks can lead to collapse and a phenomenon known as 'rockburst'. Until now, all miners could rely on was experience and intuition to tell them what is hidden beneath a rock surface, so a means of assessing the rock conditions and the integrity of underground supports would be of great benefit.

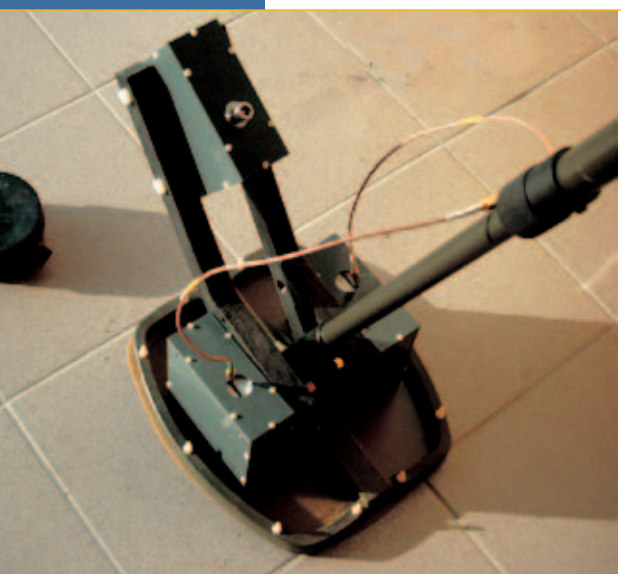
Based on the work of Ginger, RST Radar Systemtechnik of Switzerland and MIRARCO of Canada developed CRIS, a dedicated ground-penetrating prototype radar, to detect cracks in the walls and roofs of mine drifts. The radar can look through metal mesh and spray-on linings and can identify cracks ranging in depth from a few millimetres to more than one metre. A hand-held CRIS prototype has been field-tested and has successfully met all design targets. Future work will concentrate on perfecting the device for use in the harsh underground environment.

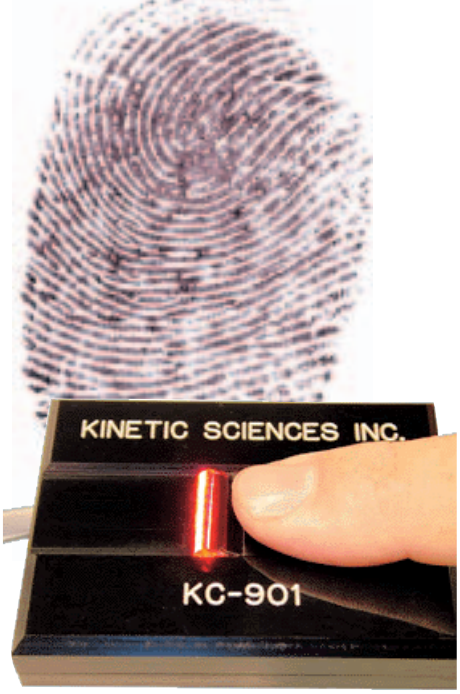
REVEALING HIDDEN DANGERS

Ground-penetrating radars also hold great promise in another area. A lot of ingenuity has been applied to making anti-personnel landmines virtually undetectable and, each year, their removal has a high cost in terms of injuries and loss of life.

Now, four industrial partners - Vallon, RST, Spacebel and Bats - and four research organisations - DLR, RMA, ONERA and ISL - have joined forces with the Universities of Karlsruhe, Bochum and Milan to create HOPE - a hand-held multi-sensor landmine detector. It consists of a metal detector, a radiometer and a ground-penetrating radar. The aim is to reduce the number of false alarms when detecting mines, thereby speeding up the process and improving safety for operators. The 5 million Euro development cost is being partially funded by the Schweizer Nationalfond and the European Union, with a further 50% from industry.

So far, the results are very promising. The device detects foreign bodies including plastic mines by collecting radar data under the ground in horizontal slices; advanced off-line techniques can then be employed to generate 3D imagery. A prototype system in Bosnia has successfully detected small landmines to a depth of 400 mm.





FINGER PRINTS ARE THE KEY

Who hasn't lost a key or forgotten a security password? Yet why should we rely on these artificial aids when our fingerprints carry our personal identity code? Now, a device that can recognise the unique pattern of ridges and whorls on our finger tips is about to become reality.

Many attempts have been made to create a reliable fingerprint sensor, but all have suffered from problems. Some were simply too fragile to cope with the harsh everyday operating environment found outside the laboratory. Others wore out quickly or were too sensitive to moisture and heat. Even the variation between a wet or dry finger tip was enough to prevent reliable recognition. But now, a spin-off from space robotics offers a new and promising approach.

The Mobile Servicing Station forms part of Canada's contribution to the International Space Station and uses robotic technology to assemble, transport and maintain payloads in orbit. A key component is a two-armed robot that can handle the kind of risky servicing and repair tasks usually performed by astronauts on space walks. During the planning of the project, the Canadian Space Agency quickly realised that sensors showing the exact location of the work site in very close proximity to the fingertips of the robot, would be essential if its 'grippers' were to work properly. Unfortunately, no such sensors existed.

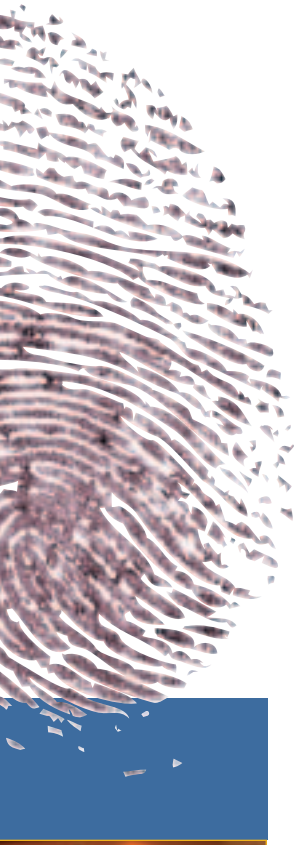
A Canadian company, Kinetic Sciences Inc (KSI), was given a contract to develop a proximity sensor that could accurately see features very close to its surface. What was needed was a device that could provide detailed information on the position and distance of objects from actual contact to 10 mm away from the robot's fingertip.

Such was the success of the sensor, that KSI foresaw much wider commercial application. With the sensor at the heart of a fingerprint reader, there was an immediate market for the device for law-enforcement and computer-security applications. In the longer term, its potential to create 'keyless' locks would be considerable. As a result the KSI Fingerprint Biometrics Division was formed and its first product was the KC-901 fingerprint sensor. A range of follow-on applications aimed at computer security, e-commerce and keyless locks is currently being developed.

A SAFER MOBILE PHONE

Mobile phones are just the latest contributors to the sea of electromagnetic radiation in which we are all immersed. The nature of the cellular system means that many base stations are needed to provide coverage over the wide areas served, and their effectiveness is strongly affected by local conditions. The need to offer users a good service must be offset against the need to limit stray radiation and protect the public against the possible effects of prolonged exposure. From a practical point of view, effective management of this electromagnetic pollution requires tools to optimise the radio-frequency levels that will be generated by base-station transmitters.

Since 1989 an Italian company, Space Engineering SpA, has been developing techniques to analyse and model electromagnetic fields from spacecraft antennas and their effects on nearby equipment. These checks on antenna performance and electromagnetic compatibility, which are vital to avoid malfunctions in sensitive onboard electronic systems, have formed part of several European space projects including Artemis, Meteosat Second Generation and Italsat.



On Earth, propagation of the very-short-wavelength signals used for telecommunications can be badly affected by the presence of buildings, trees and even rainfall. Some ten years ago, Space Engineering SpA successfully turned its satellite expertise to modelling the complicated and difficult conditions experienced by mobile receivers in urban locations. The models were validated at the ESTEC Compact Antenna Test Range on a simulated urban site and, in 1998, Space Engineering spun off Teleinformatica e Sistemi srl (TeS). The aim of the new company was to exploit the know-how derived from the space work in the rapidly expanding commercial communications market.

This know-how resulted in a system called Quickplan, which was developed to fulfil the needs of both radio-system developers and environmental agencies. The system can calculate and display radio-frequency field levels across a highly complex urban environment, indicating both the optimum locations for transmitters and the resulting electromagnetic pollution. Additions and changes to the transmitter network or the cityscape itself can then be easily dealt with - as can the allocation of transmitter frequencies to avoid interference between channels.

Since network planning and radio engineering are all about geography, Quickplan draws upon multiple maps and a powerful graphic interface to create a 3D image of the territory. Each model can be tuned using actual measurements to validate the calculations. With its powerful editing and zoom capabilities, the result is a recognisable and easily understood 3D map of the location, with colour coding that clearly identifies regions where radio-frequency power levels are above or below the desired thresholds.

This successful transfer of space-based expertise has proved a powerful aid for planners of radio systems to reduce their environmental impact and improve the meeting of our seemingly insatiable demand for new services.

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 the 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.

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

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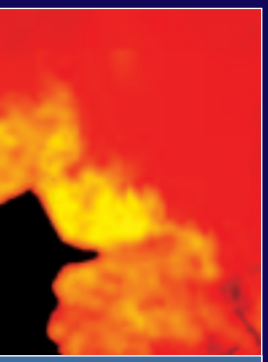

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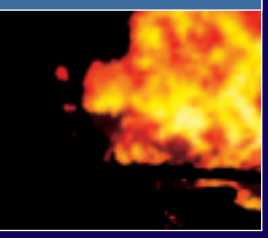

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