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MINING, OIL & GAS

Technology Transfer Programme

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What do mining, oil, gas and satellites have in common? This brochure will help you find out, and tell you just how European space industry is having an increasing impact on underground management.

Several of the technologies used in the mining and the oil and gas industries 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 underground resources, not only to improve their quality but also to make them always available.

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 mining and the oil and gas industries are not the only sectors 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

Space is a cold and uninviting place. Just getting there is a major struggle. Engineers and scientists have to spend a great deal of time and money making sure that each item of technology or equipment can cope with both the rigours of the journey and the severe demands of the environment. In addition, when things go wrong, the final destination is totally beyond the reach of even the most dedicated repair technician's call-out service!

What is unmistakable is that technologies developed for the space programme and its missions are often ideal for operation in some of the most challenging working environments on Earth. Typically these are found in the industries that deal with locating and exploiting our Earth's natural resources, such as mining, quarrying, oil exploration and forestry. In order to help ensure that such industries could benefit as much as possible from space research, in 1997 ESA launched the Harsh Environments Initiative (HEI) to identify, transfer and adapt space technologies to operations in harsh terrestrial and marine environments.

THE HARSH ENVIRONMENTS INITIATIVE

The prime contractor for the Harsh Environments Initiative is a specialist R&D company called C-CORE based in Canada. Currently, the HEI consists of four main programmes: oil and gas, pipelines, mining, and forestry/pulp and paper. Each programme addresses specific challenges faced by that industry and applies leading-edge technologies to help solve technical problems. More recently, the HEI has spun-off a European node, managed by the Norwegian Geotechnical Institute, which is applying space technologies to the offshore oil and gas platform industry, tunnelling and mining, and the Arctic environment.

Now more than ever, companies are driven to reduce costs and improve efficiency, whilst simultaneously increasing safety and reducing adverse effects on the environment. The HEI has helped many technologies originally developed for space to meet the needs of such companies. For example, Earth-observation satellites have been adapted to help survey and monitor tens of thousands of kilometres of oil pipelines, where the early detection of threats to pipeline integrity can save vast sums of money. In a mining application, radar instruments designed to guide roving planetary vehicles and undertake subsurface exploration are being modified to provide enhanced, high-resolution views of operations where visibility is extremely poor.

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THE VIRTUAL GAS PLATFORM

Early in the development of any complex system, a designer needs to be reassured that the final product will perform as required and be safe. Experimenting on a real prototype system in the early stages of design can, however, be risky, expensive and time-consuming. Increasingly, therefore, system designers use computer simulations to analyse, test and perfect their designs.

ESA, of course, sponsors the development of significant numbers of satellites, launchers and ground-support systems, and computer simulation is thus a frequently used tool during the design process. Now software for simulating space operations is being applied to extracting and processing natural gas from the North Sea.

It was because simulation is used so much - and because of the need to avoid duplication of effort - that, early in the 1980s, ESA sponsored the design of an all-purpose simulation package. The resultant package, the ESA Simulation Language (ESL), was developed by ISIM (International Simulation Ltd.) and the University of Salford in the UK. The modular package reduced the simulation process to a series of standard subroutines that can be linked together to simulate the requirements of any specific complex system comprising electrical, mechanical or software elements. Designers can therefore choose from a common tool set rather than having to design the simulation from first principles each time.

ESL, now marketed by Cogsys Limited, has subsequently been widely used within the European space community for nearly twenty years. As it is both modular and multi-functional, Cogsys have promoted it for use in other industries also. One of the first non-space users of ESL was BG International (formerly British Gas) who, with offshore partners, was exploiting the Armada group of gas fields under the northern part of the North Sea. ESL was used to design production facilities that received and processed gas from three separate adjacent fields. Very simply, ESL allowed strategies to be developed for controlling the gas flow and capacity - off-line and in safe, controlled conditions.

A further use for ESL has been in producing a training simulator for the company's gas-production platform in North Morecambe Bay. The Morecambe platform is not normally manned and is largely controlled from the mainland. The training simulator is used to train operators and engineers in operating platform facilities such as processing, fire and gas and utilities systems, and in emergency procedures.

A CLEAR VIEW DOWN HOLE

Oil is one of the world's most important resources for providing energy and chemicals, and oil companies are always looking for ways to cut costs and improve efficiency. One potentially valuable aid is being developed by the UK-based company Proneta. This is a camera that can see through oil. This means that it can be used to carry out remote inspections in oil wells and pipelines without having to clean out the oil first.

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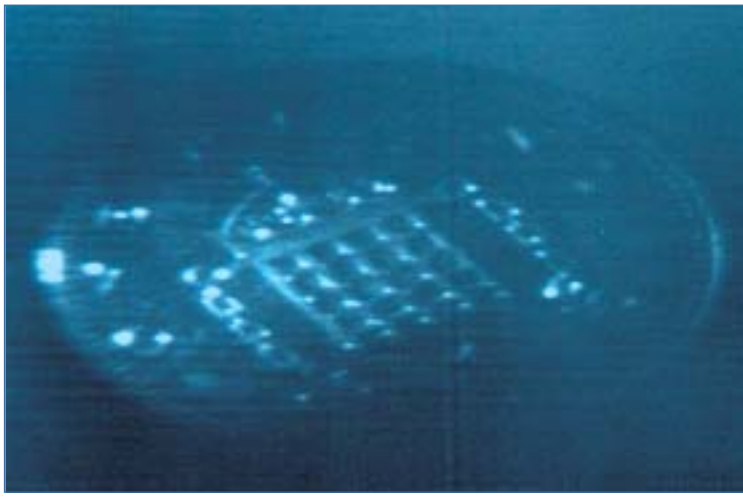
Conventional video cameras are regularly employed to diagnose problems in drilling and installations. However, they cannot see through the oil, so can be used only after all the oil has been flushed out first with a continuous supply of brine. The cost of the flushing is huge, and the delays caused by transporting the pump and filter equipment to the rig may mean that it is just too expensive to bring in a ‘down-hole’ camera.

Proneta's answer was to use its experience in the space industry - particularly in designing electro-optic instruments - to develop a camera with sensors that could penetrate oil. The company already had experience of suitable sensors used on remote-sensing satellites such as ESA's Envisat and ERS missions. These satellites monitor the environment, climate, and changes in sea level. Through exploratory tests, researchers at Proneta identified the relevant properties of oil that enabled them to design a camera that could achieve useful images. They also established that the equipment could be engineered to withstand the severe environment and the tight constraints on size and bandwidth.

Proneta then had to demonstrate that the camera really would work beyond paper calculations or computer modelling. So, with part-sponsorship from ESA, the company built a test-rig in their laboratory to produce pictures to show to oil companies and other prospective sponsors.

Proneta's key patent for the new technology has now been fully granted. Four major oil companies - Shell, BP, Amerada Hess and Chevron - are already supporting the development of a full-scale demonstrator, in which the camera will be shown working with real targets.



A MORE RELIABLE CAT

Laboratory experiments on the International Space Station (ISS) and crawlers used in pipelines have both benefited from ESA research. As the duration of a Space Shuttle flight is typically less than two weeks, facilities designed for conducting experiments on board the Shuttle's Spacelab are generally used only for short periods. By contrast, on board the International Space Station, the experiments are likely to last many years and so their design has to be fundamentally different. ESA has, therefore, led the development of new design concepts to improve safety and reduce the time required for the astronauts to carry out maintenance and calibration of equipment.

One of the companies helping ESA was Norwegian-based Prototech. By identifying potential failure points in the Spacelab design, the company was able to improve significantly the reliability, accessibility and performance of experiment modules for the ISS. For example, the pressure tubing used in the Spacelab experiments was replaced by a novel compact manifold system. Other operations such as the exchange of filters, calibration procedures and leak testing were also improved.

However, Prototech's activities were not confined to space applications. The company also designs and manufactures equipment for the inspection of offshore pipelines. The results of failures may be as critical in these operations as in space, so Prototech exploited the technology developed in collaboration with ESA to improve the reliability of tools for pipe inspection. One example is the redesign of a crawler (called a Pipecat) used to pull ultrasonic inspection tools through oil pipelines. The crawler uses two sets of pads - one is pressed to the tube wall while the other set moves forward. Using the same design techniques as for the space systems, the number of failure points was significantly reduced, and the redesigned system was made more compact and reliable. This is resulting in significant savings for oil companies in terms of equipment maintenance and retrieval costs.

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 planes 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 radar prototype, to detect cracks in the walls and roof of mine drifts. The radar can look through metal mesh and spray-on linings and can identify cracks from a few millimetres to a depth of more than one metre. A hand-held CRIS prototype has been field-tested and has successfully met all design targets.

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SAFER MINING

Mining operations and robotics are extremely fertile fields for space technologies and the HEI. One of the most promising projects involves a Belgian company, Space Applications Services (SAS). Under an ESA contract, SAS developed expertise in Man/Machine Interfaces (MMI) and created a suite of software programs (called FAMOUS) designed to control the preparation, planning and execution of robotic operations. The HEI and ESA's Technology Transfer Programme have been key factors 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 still have a number of drawbacks. For example, incorrect information and delays in receiving information can lead to collisions. The primary objective of this project is to convert 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 various machine sub-tasks, such as loading and dumping, and navigation. In a series of projects based on Sensori-Motor Augmented Reality for Tele-robotics or SMART, space-based technologies such as MMI, ground penetrating radar, loss-less data, image compression and space robotics, will be integrated to control individual machines, while a supervisory system that can simulate particular events will be developed by C-CORE. This will lead to more efficient deployment of machines by optimising the use of shared resources such as tunnel intersections and rock-dumping sites.

MATERIALS THAT REMEMBER

What about tough space materials that return to their original shape and can break rocks? Shape Memory Alloys (SMAs) are just 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.

The European space programme developed SMAs for use as lightweight, temperature-controlled actuators. The unique features were, however, showing great promise for a number of other fields such as mining, demolition and quarrying.

Forces sufficient to fracture rock are exerted as SMAs revert to their 'remembered' state. This phenomenon can be successfully harnessed to quarry marble. In practice, a row of holes is drilled along the line to be cut and cylindrical SMA actuators are inserted. The actuators are then heated electrically to restore their 'remembered' shape and the rock is simply forced apart. SMA forces can be focused far more accurately than those of traditional explosives and the resulting marble blocks require much less effort for finishing.

D'Appolonia, the Italian member of the Spacelink group with considerable experience in geo-technical engineering, realised that developing the quarrying application would be an ideal project for a European consortium. The company Ripamonti, which had been manufacturing mining equipment since 1970, became a lead partner in an EU-funded CRAFT R&D project. In addition to Ripamonti and D'Appolonia, eight companies from Italy, Spain, Portugal and the UK also became involved. The team, with expert advice from Brunel University and Duomo (an organisation dedicated to the maintenance of Milan's magnificent marble cathedral), successfully demonstrated that quarrying applications using Shape Memory Alloys could be competitive. Meanwhile, field trials with full-scale blocks of stone have validated the system design under realistic harsh working conditions.

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 120 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 12 new companies have been created, with 25 expected by 2003.

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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