BR-184 (V)
June 2002

esa

VIBRATIONS

Technology Transfer Programme

Technology Transfer Programme

What do vibrations 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 vibrations.

Several of the technologies used in various 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 problematic vibrations, not only to monitor them but also to avoid them 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 vibrations management 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

It seems that the complex demands of space exploration stimulate the need for innovation in an almost inexhaustible range of technologies. It is not surprising that the resultant spin-offs penetrate all sectors of industry - bringing wide-ranging benefits to business and our everyday lives. For instance anti-vibration technology developed from space platforms is finding wide application in building construction and instrumentation markets. Vibration is a problem that is always with us. From wind and traffic vibrations that can damage large bridges to the minute nano-perturbations that affect our most sensitive instruments, its consequences can range from mere inconvenience to total system failure.

A SMOOTHER RIDE IN SPACE

In space, problems with very small vibrations are particularly acute. Weight must be kept to a minimum and increases in the strength of high-performance materials are often not matched in terms of their stiffness. Engineering has evolved lighter but more flexible and vibration-prone structures. Unfortunately, satellite instruments usually focus their attention on small objects at very great distances, so that any local disturbances become greatly accentuated. Yet these same instruments must often rely on motors and moving parts which excite the very vibrations that impede performance.

The active damping of a truss structure using piezoelectric actuators was successfully demonstrated as early as 1989 and attracted interest from the European Space Agency. This early success led to several collaborations with European aerospace companies and research laboratories and an in-orbit active damping experiment was flown in 1995 (CFIE). From this beginning, Micromega Dynamics was formed in 1999.

Micromega Dynamics is a spin-off company of the Free University of Brussels (ULB) and specialises in the area of active vibration control. The Department of Mechanical Engineering and Robotics at ULB has been tackling the control of vibration using active systems. Their approach is based on mechatronics - a science that combines mechanics, electronics and software. Sensors are used

to detect unwanted vibrations and, through a control loop, electromechanical actuators are used to cancel them out.

Today's instrumentation and production processes routinely call for amazing precision, often down to optical wavelengths, and it is here that active damping techniques find wide application. Currently, Micromega Dynamics is involved in an ESA project that calls for in-orbit testing of a long-stroke, high-resolution optical positioning device. When it is realized that the 'long' stroke referred to is just one millimetre and the 'high' resolution is a staggering one millionth of a millimetre, the technical challenge is clear!

GETTING RID OF BAD VIBRATIONS

At the opposite end of the scale, Micromega is also investigating active damping technology to control long cable supports such as are used in space station construction and suspension bridges. Cable-stayed bridges already span 750 metres and in future may exceed 1000 metres. These structures are very flexible and, as a result, they are sensitive to wind and traffic-induced vibration. To improve their structural damping, Micromega place an actuator at the end of each cable and, obeying signals from an associated sensor system, these actuators exert a force which counteracts and cancels incoming vibrations.

Cable structures are increasingly common in large construction projects, including guyed towers and the roofs of large buildings, and their integrity is widely taken for granted. Active vibration damping, based on space technology, offers a safe route to building even larger and lighter structures with the same degree of confidence.

A CONCRETE SOLUTION TO UNWANTED VIBRATION

A technology developed to protect satellites and space structures from vibrations during launch is making life a little bit quieter on building sites. Why? Well, have you ever stopped to wonder why concrete mixers are so noisy? They might make life easier for bricklayers, but the racket they make is unpleasant and potentially damaging. In fact, mechanical shocks occurring in the mixers due to the rough contact between the gears and the driving crown cause the tank to vibrate and act like a bell. Edil Lame, an Italian manufacturer of concrete mixers, has been investigating possible technical solutions to reduce the noise. Unfortunately, these approaches have not proved to be reliable, mainly because of the poor conditions in which the systems have to operate (e.g. dust, water, weight of the mixed materials, and so on).

However, d'Appolonia, the Italian representative of the Spacelink Group, found the answer in space technology. The French company ARTEC Aerospace had developed SPADD (Smart PAssive Damping Device) to protect satellites and space structures from vibrations during launch. ARTEC had already seen the potential in adapting the technology for damping systems needed for a range of other applications including, electronic circuit boards and tennis racquets.

D'Appolonia made the introduction and, based on the successful results of a feasibility study supported by the ESA Technology Transfer Programme, a contract has now been signed between ARTEC and Edil Lame for the manufacture and marketing of the first batch of 1000 SPADD devices. Edil Lame expects to introduce the SPADD device into as many as 5000 mixers a year.

SENSING UNWANTED VIBRATIONS

When car parts or washing machines vibrate we normally treat them as little more than annoying inconveniences. Vibration in industrial machinery, however, is much more serious. It may indicate expensive and potentially dangerous failure of vital pieces of equipment. But now, tiny sensors from space are helping to warn of potentially catastrophic equipment failure.

The German company Ops Automation recognised the need for a vibration detector that was robust and inexpensive and could be applied to a wide range of industrial machinery. At the Hanover Fair in 1998 the company noticed the tiny sensors exhibited by another Germany company, Mirow. These had been developed for the aerospace industry and were based on piezofoil technology. Piezofoils are transparent plastic films which develop an electrical charge when a mechanical stress is applied. The effect depends on direction, so piezofilm sensors are excellent at detecting pressure fluctuations, vibrations or force changes.

The sensors were extremely sensitive and reacted quickly. They had been employed by Mirow and the Technical University of Berlin to sense, for example, pressure changes which indicate what is happening to spacecraft as they pass through the Earth's atmosphere.

Ops Automation realised that piezofoil sensors had potential as industrial vibration detectors, but that further development was needed to produce a marketable product – a cheap, strong device that could be mass-produced. Since Mirow did not itself have the resources to undertake the work, it was carried out by Ops Automation with support from ESA, and culminated with a patent application on the design in 2000.

In parallel with the design of the sensor, Ops Automation also developed an intelligent signal-processing unit which could analyse the frequencies of the characteristic vibration that a machine generates. If any defects occur (such as bearings breaking up) the noise changes and can then be monitored. It is the combination of the vibration detector and the noise-analysis unit that gives operators advance warning of impending machine failure. Called VIBROSYS, the system is now being used in a variety of applications such as monitoring the huge numbers of pumps employed in the petro-chemical industry, and in many other machines used by various processing companies.

After securing 860 kEuro of venture capital, Ops Automation transformed itself into a public company. As well as creating at least 20 new jobs, the company is expected to have a turnover of around 20 MEuro by 2005. Like the launch vehicles, this space technology transfer business has really taken off!

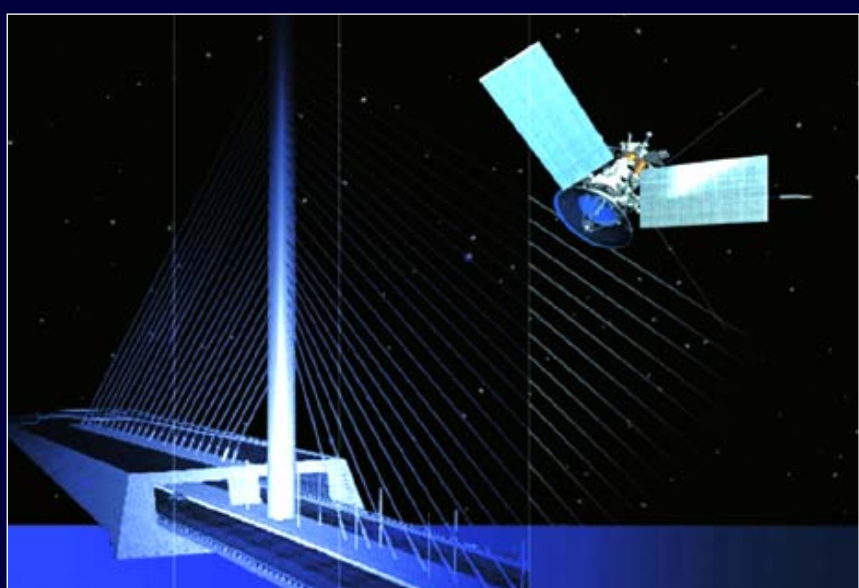
Benefits for our daily lives: the ESA Technology Transfer Programme

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 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:

Dr. P. Brisson
Head of the Technology Transfer and Promotion Office
European Space Agency-ESTEC
P.O. Box 299
2200 AG Noordwijk
The Netherlands

Tel.: + 31 (0)71 565 4929
Fax: + 31 (0)71 565 3854
E-mail: pierre.brisson@esa.int

Dr. D. Raitt
Technology Transfer and Promotion Office
European Space Agency-ESTEC
P.O. Box 299
2200 AG Noordwijk
The Netherlands

Tel.: + 31 (0)71 565 3017
Fax: + 31 (0)71 565 3854
E-mail: david.raitt@esa.int

or contact one of the Technology Transfer Network brokers:

MST Aerospace GmbH
Eupener Str. 150
D-50933 Cologne, Germany
URL: http://www.mst-aerospace.de

Tel.: + 49 (0)221 949 89 20
Fax: + 49 (0)221 491 24 43
E-mail: office@mst-aerospace.de

JRA Aerospace & Technolgy Ltd.
JRA House, Taylors Close
Marlow, Buckinghamshire
SL7 1PR, UK
URL: http://www.jratech.com

Tel.: + 44 (0)1 628 89 11 05
Fax: + 44 (0)1 628 89 05 19
E-mail: mail@jratech.com

D'Appolonia SpA
Via San Nazaro, 19
I-16145 Genoa, Italy
URL: http://www.dappolonia.it

Tel.: + 39 010 362 81 48
Fax: + 39 010 362 10 78
E-mail: info@dappolonia.it

Nodal Consultants
209-211, rue de Bercy
F-75585 Paris Cedex 12, France
URL: http://www.nodal.fr

Tel.: + 33 (0) 14 002 7557
Fax: + 33 (0) 14 002 7544
E-mail: info@nodal.fr

or visit the ESA Technology Transfer Website: **http://www.esa.int/ttp**

or the ESA-supported technology market places: **http://www.technology-forum.com**

and **http://www/t4technoline.com**

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. : 92-0920-722-4