



Funded projects

**Leading Edge Technologies reserved to SMEs
Innovation
Transfer of Technology**

European Space Agency

Agence Spatiale Européenne

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Green Hydrogen Peroxide Monopropellant in advanced Catalytic Beds

Keywords:	Hydrogen Peroxide, Catalyst Bed, Monopropellant Rocket Engine
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Name of Program:	LET-SME
Year:	2005
Overview/Scope of the activity:	<p>The scope of the project is the development of a high concentrated hydrogen peroxide based monopropellant thruster which should be of special relevance for micro-satellites.</p> <p>Currently, a large fraction of space mission costs consists of safety procedures required for handling toxic and sometimes also carcinogenic propellants (i.e. hydrazine). The use of less toxic propellants ("green propellants"), such as hydrogen peroxide, would not only bring significant cost savings, but would also have a favourable impact in the cost reduction and time savings of spacecraft developments. Moreover, hydrogen peroxide can be used not only in a monopropellant thruster, but also as oxidizer in a bipropellant rocket engine. The team has focused on the progress of a monolith decomposition chamber. The monolith decomposition chamber has the benefits of a reduced pressure drop through the catalyst bed in comparison with; for example; catalyst in pellets or foam shapes. This results in a greater fraction of pressure energy exploitable for propulsion. The team is also studying the development of a suitable modelling tool for the decomposition of hydrogen peroxide.</p>
Application Fields:	Recently, micro-satellites have gained a strong attention, first, because they have shorter development times and secondly, for their ability to get "piggy-back" launches which offers a strong mission cost reduction. All these benefits have produced an emerging new space market opportunity for miniaturized and low costs spacecraft sub-systems. Therefore, there is an emerging demand for reliable, miniaturized and low cost propulsion system to be used for the orbit and attitude control of small spacecraft.
Improvement to the state of the art:	<p>According to the identified possible space missions for a HP monopropellant rocket engine the main advancements which are proposed would enhance the intrinsic benefits of a HP monopropellant rocket engine (i.e. low power demand) and would improve the actual disadvantages (i.e. mission lifetime):</p> <ul style="list-style-type: none">• Decreasing catalyst poisoning sensitivity. This would allow to use a HP with higher stabilizer concentrations and in turn it would allow longer lifetime space missions.• Miniaturization of the rocket engine in order to satisfy the volume constraints typical in small satellites.• Low pressure drop in the catalyst bed.• High thermal stability in operating conditions for long term use.• High activity even after long term storage.• Decrease in electrical power requirements (avoid catalyst preheating at start up).• Decrease in thrust noise due to decomposition pressure oscillations.• Reduction of firing pulse width.
Achievements:	<p>The project succeeded in developing an engineering model of a monopropellant thruster. It was shown that the use of monolithic catalysts results in a highly efficient decomposition (up to 99%) of hydrogen peroxide. Performance evaluations verified a vacuum thrust range between 150 to 900 mN at a specific impulse of 153 s. Analytic evaluations of these results show the potential to obtain a specific impulse of 164 s and a thrust up to nearly 1 N. Experimentally verified is a catalyst lifetime sufficient to decompose 1.2 kg of hydrogen peroxide. This corresponds to a total impulse of 1900 Ns. Sole limiting lifetime factor during this evaluation was shown to be related to a cracking of the monolith (see problem areas below). Avoiding such monolith damage, the experimental results indicate a total lifetime sufficient to decompose up to 5.5 kg of hydrogen peroxide, corresponding to a total impulse of 7500 Ns</p>

High Precision Diagnostic Device

Keywords: Photogrammetry, Camera, 3D, 3D Measuring System, Precision Measurement

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Name of Program: ToT
Year: 1999

Overview/Scope of the activity: The objective of this activity is the transfer of a photogrammetric measurement demonstrator developed for fluid dynamics application on the ground and in space to an industrial 3-D Measurement System. The work is split into two phases. Phase I: to design and build a hand held photogrammetric camera head. Phase II: To perform verification tests to define calibration strategies, measurement procedures and a variety of tooling accessories for the system to achieve a maximum performance when entering the market.

Application Fields: Mobile industrial applications (car industry, bus and truck manufacturing). The transportation of items to fixed locations for measurement is time-consuming leading to delays and interruptions of production procedures and to extended set-up times. A mobile 3D Measuring System will avoid these problems. The low-cost system could reach a very wide market and could find its way to new media, internet technologies as well as housing and architecture.

Improvement to the state of the art: Compared to the general photogrammetric set-ups with three or more cameras at very different positions, this approach works with one main observation direction. A high resolution camera equipped with a fixed probe tip can measure the 3D positions with the required accuracy. This device offers a quick and flexible control on the shop floor, avoids expensive production interruptions and reduces set-up times to a minimum.

Achievements: Phase I: A prototype has been set up. The housing, the camera and the illumination device have been put together with respect to simple production methods designed for low cost manufacture.
Phase II: The complete 3D Probe has been tested and verified against the requirements defined in work packages. Several tests have been carried out in selected factories (DaimlerChrysler, MAN, Volkswagen, etc.), and have achieved excellent results. AICON is already planning to sell the developed highly accurate mobile measurement tool to automotive and bus companies. German, European and US patents have been granted. It is now intended to market this product on a world wide base using the AICON distributors network.

Low Power, Small Hall Effect Propulsion System

Keywords Electric Propulsion, EPS (Electrical Propulsion System), Hall Effect Thruster, Microsatellite

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Name of Program: LET-SME

Year: 2005

Overview/Scope of the activity :

The scope of the proposed work is to develop and test the main breadboard/EM-level sub-systems for a small low power (50-200 W), low cost Hall effect propulsion system. The envisaged breadboard/EM system would be composed by three main sub-systems/components, namely: the thruster core (anode unit, AU), the neutralizer (cathode unit, CU), the power supply and control unit (PSCU). The AU and CU compose the thruster unit sub-system. In the framework of the envisaged activities the EM AU and the breadboard PSCU will be specifically developed for the present project, respectively by Alta and by SkyTech. The CU will be procured as an off-the-shelf item from an external supplier. System responsibility will rest with Alta, which will also be in charge of assembly, integration and testing (AIT) activities aimed to the detailed characterisation of the integrated EPS performance.

Application Field :

In the framework of this activity miniature Hall effect thrusters in the 60 to 200 W power range applicable for their compact design and low power-to-thrust ratio resulted to be particularly attractive for intermediate delta-v applications (200 to 2000 m/s, typical) with respect to other EP concepts and chemical propulsion. A reference science mission based on 120 kg spacecraft fitting the ASAP 5 launch requirements, located on the L2 (Sun-Earth internal) libration point, requiring about 2000 m/s delta-v for the orbit transfer from GTO was studied in detail within the MEPS activity but several other applications were identified requiring small HETs as primary and AOCs propulsion system. For these reasons the PSCU (Power Supply Control Unit) will be compliant with the requirements for possible applications, which will include (but not be limited) to the requirements for CNES Microsatellite product line (Myriade bus), Carlo Gavazzi Space MITA bus, Surrey Satellite Technology Ltd GEMINI bus which represent the available candidate platforms for near term applications.

Improvement to the state of the art

The AU and PSCU design will be based on the results achieved in the framework of Alta's XHT-100 : programme, aimed at the development of a technology demonstrator with a nominal power level of 95 W. XHT-100 is presently the only low power Hall effect thruster under development and testing in Europe. The XHT-100 thruster was an attempt to extend the Hall thruster qualities (reliability, simplicity, compactness, performance) also in the low power range (100 W and less) where the results previously obtained all around the world were not completely satisfactory especially in terms of efficiency. In particular the main activities on the thruster unit will be aimed to further improvement of efficiency at lower power levels, the beam divergence and lifetime, by the optimisation of the magnetic circuit (based on proprietary permanent magnets differently from classical solutions using magnetic coils) and by an highly integrated propellant distribution system. At system level the efforts will be mainly focused to improve the simplicity, compactness and modularity of the whole EPS (i.e. possibly choosing a non conventional thermoionic cathode instead of the hollow type) in order to fulfil the requirements for the most demanding applications both in terms of performance and costs.

Achievements:

The present activity allowed the design and manufacturing of 2 thruster units and of a breadboard of the power supply required for its operation providing useful information for the design and the optimisation of the future EM and EQM models. An extensive experimental work has been carried out during the programme in order to characterize the performance of the thruster alone and when coupled with the power supply breadboard evidencing the critical aspects of the power supply design and the optimization of its circuitry (especially in terms of robustness). Direct thrust measurements and beam diagnostics, in fact allowed a precise definition of an extended operating envelope in terms of thrust, efficiency, specific impulse of the unit providing useful data for the detailed analysis of the missions requiring this propulsion technology. An endurance test of more than 100 hrs was carried out to provide validation of the erosion models and prediction of the expected lifetime. This test also allowed the verification of the thermal models and the validation of the use of permanent magnets for the generation of the magnetic field. In support to the permanent magnet validation, in the framework of this activity a 1500 hr thermal cycling test (from 100°C 400°C) was carried out to provide the time evolution of the coercive force following repeated heating to high temperatures. Different test campaign were also carried out using different technologies for the cathode neutralizer providing an insight of the effects this component has on the thruster's performance and providing material for comparison of these different technologies. Finally the twin engine test, including the simultaneous operations of two thrusters (first test of this kind in Europe on Hall thrusters) provided extremely important quantitative information about the operation of Hall thrusters working in cluster mode and about the mechanisms of beam neutralization which will be useful for the future development of clustered propulsion systems.

Green Hydrogen Peroxide Monopropellant Rocket Engine with Advanced Catalytic Beds

Keywords Chemical Propulsion, H₂O₂, Hydrogen Peroxide, Monopropellant Thrusters, Catalytic Beds, Green Propellants, Ceramic Carriers

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Name of Program: LET-SME

Year: 2005

Overview/Scope of the activity :

The scope of the activity is to design and test the prototype of a hydrogen peroxide monopropellant thruster of low-medium thrust level (5-25 N), with particular interest in the development of a catalytic bed having good activity and c^* efficiency, able to sustain a large number of thermal cycles with acceptable performance degradation and resistance to poisoning.

Application Field :

The characteristics of rocket engines using hydrogen peroxide make them particularly attractive for low and medium thrust space applications and, in particular, for LEO commercial or scientific satellites and for some interplanetary scientific missions. In these cases the requirement for a lower power level is driven by budget considerations, but the components are typically designed in order to obtain the best possible performance: the trend during the last years has been towards miniaturization and reduction of the life-cycle costs.

Improvement to the state of the art

The most important improvements to the present state-of-the-art in the design of hydrogen peroxide monopropellant thrusters will be related to the catalytic bed and the corresponding injection mechanism. With the aim to solve some of the most significant problems typically observed in past hydrogen peroxide thrusters, the objective is to find the optimum compromise between the resistance to poisoning and clogging, the minimization of the pressure losses, the avoidance of propellant flooding and flow channeling, and the attainment of adequate transient response and repeatability. These aspects impose conflicting and coupled limitations to the various characteristics of the catalytic bed, namely the bed length and cross-flow dimensions, packing, permeability, active surface area and flow pressure losses.

Achievements:

The activity has allowed for carrying out an extensive research on advanced catalysts for hydrogen peroxide decomposition and for developing a very effective deposition procedure on ceramic substrates. A series of catalysts on ceramic supporting spheres have been prepared by means of different implantation techniques developed by ALTA S.p.A. in collaboration with the Chemistry and Industrial Chemistry Department of the University of Pisa. These catalysts have been tested using a specific test bench designed and assembled by ALTA for the characterization of the activity and reaction rates. The developed Platinum based catalysts have showed to be very active and to not suffer poisoning problems. A propellant supply plant and a custom-made test bench have been specifically designed, manufactured and assembled. The experimental campaign has allowed for testing the 5 N monopropellant thruster prototype and for studying and understanding the problems related to the ceramic catalysts when tested in the actual working condition. The critical analysis of these problems has led to the identification of possible applicable solutions. A reduced order model of the thermal transient and its consequently thermal stress inside the pellet has been performed and it has showed that effectively the thermal shock related to the high impulsive decomposition temperature seems to be the principal reason of the breaking of the pellets.

Application of SPADD technology

Keywords: Vibration, Noise, Damping, Overloads, Structure

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Name of Program: ToT

Year: 1999

Overview/Scope of the activity: The aim of the study was to find, test and qualify a device dedicated to reduce the vibration level of electronic boards, by using a generic damping technology called: Smart Passive Damping Devices (SPADD®).

Application Fields: SPADD® is a generic technology, which can be applied to all systems where vibrations and/or noise levels are to be reduced.

Improvement to the state of the art: Classical solutions are only shifting the vibration modes towards higher frequencies with stiffeners, or towards lower frequencies by adding foams and plastics. These solutions, which are not real damping, increase the overall weight and move the problems to other frequency ranges. By using SPADD® technology the structure remain unchanged (no need of additional weight or stiffening) and the vibration modes are damped. SPADD® is small, passive, and placed in parallel to the existing structures. Therefore the performances are much better than conventional solutions.

Achievements: A test campaign on one example has shown that the SPADD® Technology reduces the lower resonant modes (reduction factor of 16.7 in max. acceleration and 4.3 in displacement) and damp the higher modes leading to an overall reduced RMS level in the bandwidth with an average factor of 2.7. Combining these effects, the overall structure reliability is significantly improved (reduced fatigue, longer lifetime). Several applications are in progress in the following domains: car (engine mount and chassis), consumer appliances (washing machine), defence (helicopter, submarine), aeronautic (airplane structures, engine mount) etc. The SPADD® Technology has been improved since the end of the study. Several new shapes have been developed for various applications, including a flat profile for damping thin structures. Based on this parallel technology, a serial damping block is also developed in order to widen the field of applications.

Low Cost Modular Power Supply (Modular DC/DC converter optimised for "gyroscope applications")

Keywords: Electronics, Power Supply, DC, DC/DC, Converter, Gyroscope

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Name of Program: ARCoP

Year: 1999

Overview/Scope of the activity: Feasibility study of a modular low power DC/DC converter. Development of the breadboard of a DC/DC converter so that it could be adapted to the space environment, in terms of radiation, temperature and other requirements. The dimensions of the breadboard will be optimised and the mechanical structure developed so that it could meet the requirements of a broad range of space applications.

Application Fields: There is a general need for many space applications that require this type of power supply. This study however, targets applications in gyroscopes in particular.

Improvement to the state of the art: The commercial space qualified DC/DC converters are quite expensive and they need conditioning electronics to be suited for the specific application. The programme aims at developing a low cost modular DC/DC converter optimised for "gyroscope applications".

Achievements: The outcome of this feasibility study is that the originally proposed topology doesn't work properly and changes were necessarily implemented leading to a more conventional converter topology. The test results show some good points of the converter that, with some improvements, could be attractive for application like the Fibre Optic Gyroscope. However, the idea to make a competitive general purpose DC/DC converter was abandoned. ATERMES achieved some encouraging results. The estimated recurrent cost of the industrialised version of the converter is 16.8 k€, hence lower than 30.5 k€ which is the cost of the present solution.

Investigation and Development of High Performance Computing Applications in Non-Space related Areas

Keywords: Computing, Remote Sensing, Software Applications

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Name of Program: ToT

Year: 1999

Overview/Scope of the activity: Atlantis proposes to undertake a market analysis and prototype development for Remote Sensing software applications using high performance computing outside the traditional Space borne or Airborne Remote Sensing market. Following the identification of non-space related markets for these technologies, ATLANTIS will carry out development, production, marketing and sales plans for each product and market and develop software prototypes for use in demonstration to customers and to develop interest from potential investors.

Application Fields: Development of turnkey solutions for problems in advanced image processing applications, middleware software for application developers and development of a high performance scientific analysis and programming tool.

Improvement to the state of the art: The ability to solve application problems which to date cannot be solved due to the vast volumes of data, the large computational burden required, or the enormous cost that a traditional, multi-million dollar supercomputer solution entails. The software ATLANTIS intends to market shall provide lower computing times and a cheap alternative to the supercomputer solution.

Achievements: Atlantis has identified and profiled non-space related markets in terms of customer requirements and the contribution that can be made to those requirements by the company. They have also transferred high-performance and image processing technologies from space-borne remote sensing applications to non-space related markets. Finally, Atlantis has created a development, production, marketing and sales plan for promising markets.

Qualification of a System for Parallel Computation

Keywords: Parallel System, Parallel Processing, Parallel Architecture, Programming, Programming Environment

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Name of Program: ARCoP

Year: 1999

Overview/Scope of the activity: The purpose of this project is to study applications of a software package called ARBEOS (developed by Spacebel) in the parallel processing domain. The envisaged system also consists of a parallel card manufactured by CASTOR Technologie, and will evaluate in particular use in data classification algorithms and matrix operations, with the intention of reducing processing times for large data calculations.

Application Fields: All types of applications that require parallel processing. In many domains, parallel computers have been used successfully to tackle large computations such as in fluid dynamic, signal or image processing. However, some difficulties restrict the benefit of high performance parallel systems to some high technological markets such as defence, biological or energy programs.

Improvement to the state of the art: Optimisation of the development of parallel applications. The approach changes dramatically parallel system design, as it is not necessary to use the final target to size globally a system and to predict proven performances. This has also implications in the system development lifecycle, as porting and parallel system evolutions can be controlled and assessed. Low cost would be undoubtedly the main advantage of the product. Nowadays, the environment could attract engineers discouraged by the hardware and software costs of parallel systems.

Achievements: To tackle the complexity of configuring and sizing the applications of parallel computing, a scalable parallelisation schema has been introduced. Given a trial application, the compliance of the parallelization schema with the Arbeos framework has been shown, and the expected scalability of ARBEOS has also been demonstrated. A tool called HiPerDesign has been prototyped to automate the finding of the optimised solution referring to some desired cost function (time, latency, size of architecture,...).

Integrated Software Engineering for Space Applications

Keywords: ADL, AADL, Avionics, Software, Module

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Name of Program: INNOVATION

Year: 2001

Overview/Scope of the activity: A new trend in aeronautical domain is the use of Modular Avionic components in order to maximize the modularity and the reusability of parts of the system. Such a technique makes use of new specification and design tools. These tools integrate a specific Architectural Description Language (ADL) and simulation capabilities to iteratively refine each module description while permanently testing that the behaviour of each module respects requirements and constraints imposed by the designer and the environment. The object of the activity is to propose an environment framework dedicated to space domain applications.

Application Fields: Avionics systems and software for Space, Aeronautic, Automotive, etc.

Improvement to the state of the art: This brings the current standardisation of AADL, an ADL language dedicated for avionics an automotive language, under the SAE umbrella, together with Americans, the view of the space domain. It also exercises the application of such an avionic language for a space data handling or AOCS, and seeks to improve the Language itself.

Achievements: The Language has been improved following close cooperation with Americans on standardization. An identification has been made of capabilities for formal avionic systems, with description and verification. Furthermore, a market has been opened for European verification tools researchers and tool vendors. A simulation environment based on an input system description in AADL has been prototyped successfully. As a result of this activity a major input has been made to a proposal by ESA with 30 industrial partners to EC FP6 (ASSERT).

Study on multi-agents architectures and decision algorithmic for smart automated operation
(for the IRSI LEO mission)

Keywords: Autonomy, Multi-Agents, System Engineering, Planning, Scheduling, Constraint Programming

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Company Point of Mr. T. Billoir (tb@axlog.fr; phone ext. 3101; fax ext. 0736)

Name of Program: ARCoP

Year: 1999

Overview/Scope of the activity: The purpose of this project is to evaluate and further demonstrate a promising advanced technology "Multi Agents with decision algorithms processing", within the context of a simplified mission. It is carried out in two phases.
Phase I: to develop the mathematics and software for a quasi autonomous strategy on what to do in case of unforeseen events. Phase II: to refine the resolution techniques which are being used and to provide the autonomous architectures with the maturity they need for the space domain.

Application Fields: Global Operation of a constellation or formation flying of satellites (like the future Darwin mission).

Improvement to the state of the art: Development of a technology for system autonomy, which was not conceived for dynamic environments. Data from Darwin mission shall be used in this project. System autonomy will reduce ground segment requirements, processing time, and overall mission complexity.

Achievements: The results of this R&D activity demonstrate the feasibility and benefit of the undertaken technology approach, for autonomy for Formation Flying of satellites, with DARWIN specification. The Multi-Agent System enables to model individual and group behaviours, and it is a good approach to distributed autonomous systems. Layered Planning improves mission planning reactivity by simplifying the models and optimises computing resource usage over the formation.

STEMSYS Bioreactor for clinical applications

Keywords: Bioreactor, Clinical Applications, Cell Culture, Hematopoietic

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Company Point of Mrs. K. Bizet (e-mail: bizet@bertin.fr; phone ext. 6191; fax ext. 6145)

Name of Program: ToT
Year: 2000

Overview/Scope of the activity: The initial goal of this project was to develop and manufacture a 100 ml bioreactor prototype for hematopoietic cell cultures based on an existing small model (3 ml). Nevertheless, technical assessment of the existing model have showed that some technical and biological problems remained. For these reasons, it has been estimated that the main priority was to optimise the small model in order to facilitate its industrialisation instead of developing a 100 ml prototype version.

Application Fields: Clinical applications (e.g. bone marrow transplants after ex-vivo cell amplification).

Improvement to the state of the art: One difficulty in the clinical ex vivo expansion is the determination of reproducible and reliable culture conditions. Many variables play a critical role in that field: initial cellular concentration, composition of the nutritive medium, duration of the culture... Several key parameters, however, cannot be monitored in static culture systems. The goal of using a bioreactor is to constantly control the culture's parameters (oxygen tension, pH, metabolic concentration) to avoid the depletion into nutritive factors and to eliminate potentially toxic components, without risk of contamination.

Achievements: After defining the specifications of the new bioreactor by studying culture protocols for hematopoietic cells expansion and physiological requirements, ten prototypes were made and tested. However only one bioreactor gave very encouraging results in terms of final cell concentration and mortality rates. Nevertheless, this experiment demonstrates the feasibility of the developed bioreactor to amplify hematopoietic stem cells. More testing would be necessary for assessing performances of the bioreactor, and confirm the developed biological protocol.

Solid Propellant Gas Generator

Keywords: Solid Propellant Gas Generator, Cool Gas

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Name of Program: LET-SME

Year: 2002

Overview/Scope of the activity: Solid propellant gas generators are devices that produce gas by burning a solid material. They are used for many terrestrial applications where a relatively large volume of gas is needed for a short time. A unique technology that generates cool gases directly without requiring a separate heat exchanger is presented by Bradford and TNO Prins Maurits Laboratory. The objective of this study is to identify space applications for cool gas generator technology in which this technology can give an advantage in cost, mass, volume or safety and to demonstrate the feasibility of the cool gas generator based system for one selected application.

Application Fields: Solid propellant gas generators have been used many times, for example in the Ariane 5 turbo pump starter. However, the cool gas generator technology has never been used in space and has some unique features that make new space applications possible which are beyond the scope of existing qualified gas generators. Cool gas generators may be used for example as a refill cartridge, for TVC pressurisation or as an extension mechanism for landing legs.

Improvement to the state of the art: Current state-of-the-art solid propellant gas generators produce hot gases. Before these gases can be used, they need to be cooled in a heat exchanging system. Such a separate system significantly adds weight, volume, complexity and costs to a gas generator. Bradford and TNO present a technology that generates cool gases directly without the need of a dedicated heat exchanger, which could lead to simpler, safer and more cost effective systems.

Achievements: Three applications have been selected for Cool Gas Generator technology for a detailed quantitative study: 1) a refill system for cold gas thruster application; 2) a propellant tank pressuring system; 3) a reactant supply for a fuel cell system. The refill system was then selected for further work and it was found that cost, mass and reliability factors could all be improved by application of this technology. A demonstrator has been designed to work in the cold gas tank of Nanosat-2 and has shown that the amount of pure Nitrogen held by the tanks can be increased more than 3 times to a total of 6 grams using the gas generators, whilst the maximum pressure did not exceed the limits of the existing system. The temperature of the produced gas reached less than 10C above ambient system temperature. A further advantage found was that the gas generators allow the system to be launched unpressurised, simplifying pre-launch activities. An extension to this study work has been approved to further identify and investigate possible applications. Parallel to these activities, the cool gas generator technology will be flown on the PROBA 2 spacecraft as a refill system for the on-board resistojet thruster system, achieving in-flight demonstration and qualification of this technology.

Micro-Motorisation for Medical Instruments

Keywords: Ultrasonic Motor, 3D Imaging, Piezo Drive, UPD, Micro Motorisation

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Company Point of Mr. R. Le Letty (e-mail: ronan.leletty@cedrat.com)

Name of Program: ToT

Year: 1999

Overview/Scope of the activity: The main objective of this proposal is the development of a small Ultrasonic Piezo Drive for the Micro Motorisation of Instruments, aiming to create a 3D Ultra sonic imager. This will be accomplished by developing an integrated approach to 3D imaging ultrasonic transducers where the transducer, motor, encoder, interconnection and control circuitry are designed into an unique micro-system.

Application Fields: Ultra-sound imaging and for diagnosis of diseases. In particular, the application of the Micro Motorisation of Medical Probes for 3D Ultrasonic Imaging.

Improvement to the state of the art: Existing 3D imaging systems have many drawbacks due to the fact that the rotating devices are typically add-on mechanisms, with poor precision. This project aims to overcome these drawbacks and to provide 3D ultrasonic imaging probes that will enable the users to accurately and quickly obtain multiple scanning planes for subsequent 3D image generation. Ultrasonic Piezo Drive (UPD) is a quite innovative concept that allows the building of long stroke linear motors (from 1 to more than 100mm) as well as rotating motors. UPD leads to direct drive Micro Motorisation offering the unique advantages of precise positioning, blocking at rest, low voltage and compact size.

Achievements: An ultrasonic motor -RPM60- having an overall diameter of 20 mm has been developed and two prototypes built, assembled and tested. This was tested on a specially designed test bench. The first results were quite promising, since the expected performances have been obtained on both prototype motors. However, the electrical dissipated power was found to be too high (5 W) and must be further understood, as the dissipated power leads to an excessive temperature rise. The technological background acquired on this project has also been used in an on-going Technology Research Programme on Rotary Piezo motors for Space Applications.

Piezo Valve for Space Applications

Keywords: Piezo Valves, Satellites, APAs

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Name of Program: INNOVATION

Year: 2000

Overview/Scope of the activity: This project is a demonstration of feasibility of a piezo valve based on the Amplified Piezo Actuators and accounting for space requirement. CEDRAT has already developed a series of Direct Piezo Actuators, Amplified Piezo Actuators, Piezo Motors and Piezo Mechanisms meeting space requirements. It proposes to investigate the possibility of making Piezo Valves based on the Amplified Piezo Actuators (APA) concept in order to offer small and 'smarter' valves than US piezo valve solutions, to offer a European source of piezo valves and to extend the range of applications of the APAs.

Application Fields: Due to the trend for smaller space satellites, there are needs for a new generation of small, lightweight and 'smart' valves, in several applications in the satellites. These applications are propulsion, especially in thrusters for the control of altitude in micro satellites (control of small gas flow) and also systems for thermal regulation of satellites (control of cooling fluid such as ammoniac).

Improvement to the state of the art: Expected advantages are: light-weight and small size, due to a higher energy density than electromagnetic devices; precise dosing due to a stroke proportional to the applied voltage; low-power consumption, due to the capacitive nature of the piezo actuators; short time response, due to high stiffness and low mass, and no rebound.

Achievements: A piezo actuated valve has been designed and successfully tested in ambient and thermal vacuum conditions. A flow regulation of dry Nitrogen having a turn down ratio of 1/1000 has been demonstrated. Some applications for Drag Free Attitude Control of Spacecraft have been clearly identified. The company has acquired the knowledge to design valves and to know whether a new requirement is adapted to the technology of piezo valves. A patent on several geometries of piezo valve has been filed.

Autoshield Software for Analysis of Spacecraft Shielding

Keywords: Hypervelocity impact, Debris Shield, Simulation Tool, Numerical Analysis, Smooth Particle Hydrodynamics, Lagrange Solver

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Company Point of Mr. C.J. Hayhurst (e-mail:Colin.Hayhurst@centurydynamics.co.uk)

Name of Program: INNOVATION

Year: 1998

Overview/Scope of the activity: The objective of the activity is to develop a modern simulation tool, "Autoshield", for hypervelocity impact analysis. The tool incorporates a pre-processor for model generation, solvers, and a post-processor for output of results, and should be suitable for designers in both industry and research and development organisations.

Application Fields: Numerical analysis of hypervelocity impacts on space debris shields.

Improvement to the state of the art: This tool integrates state of the art graphics interfaces with the existing capabilities of Autodyn-2D and 3D, providing all in one facilities for model generation, analysis execution and results post processing through an improved user friendly Windows menu system.

Achievements: Century Dynamics Ltd. has constructed the Autoshield software capable of model generation, analysis execution and results post-processing in 2D and 3D visualisation. Smooth Particle Hydrodynamics and Lagrange numerical solvers have been integrated with an interactive integrated Graphics User Interface to create stand alone software for analysing space debris impacts at hypervelocities on debris shields. Century Dynamics Ltd also conducted simulations of hypervelocity impact tests on aluminium debris shields, to validate the capabilities of this technology.

Technology Transfer of a Composite Material Model for Hypervelocity Impact to Non Space Sectors

Keywords: Impact, Simulation, Modelling, Composite, Transient Loads, Non-linear

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Name of Program: ToT
Year: 1999

Overview/Scope of the activity: The objective of this project is to transfer a unique composites modelling capability, developed for the International Space Station shielding analysis, to impact applications at much lower velocities, which are a serious technical problem in current and future aeroframes, automotive, rail and marine transport structures.

Application Fields: Modelling impact effects in the aerospace sector, especially birdstrike impacts to aircraft composite structures, but also engine blade impacts or explosives in cargo containers.

Improvement to the state of the art: Static finite element modelling of fibre reinforced plastic (FRP) composite materials is a well established practice and important tool in space, aerospace and other sectors. However, for such analyses the composite materials are considered to behave elastically and as a general rule linearly. Composite materials experiencing more severe transient dynamic loads respond in a very non-linear way. A previous ESA contract led to the successful development of a non-linear model for composite materials. This model, properly developed, will offer a new and valuable capability to industries where impact modelling of FRP materials is important.

Achievements: Century Dynamics Ltd. have successfully applied their previously developed AMMHIS model to four different types of composites used in aircraft structures and personnel protection systems as well as conducted simulations of birdstrike and blade impacts:
1) Woven composite generic curved structures were simulated and compared with experimental results, and a very good agreement between the simulations and the experiments was obtained.
2) Composite fibre tail leading edge materials simulations were also performed in advance of planned experiments which have yet to take place.
3& 4) The model was also applied to two polyethylene and aramind based body amour materials and both have been compared to experimental data. The results have been published by Century Dynamics Ltd.

Hybrid Ceramic Ball Bearings

Keywords: Bearings, High-Nitrogen Steel, Dry Running, Corrosion Cracking

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Name of Program: INNOVATION

Year: 1998

Overview/Scope of the activity:

In the frame of the activity, hybrid ceramic ball bearings for potential use in space mechanisms have been developed, manufactured and tested. The thin-section bearings feature ceramic balls; in this particular case, zirconia (ZrO₂) has been selected. The rings are made from a new High-Nitrogen Steel (HNS) grade offering excellent mechanical properties combined with high resistance against inter-granular corrosion and stress corrosion cracking. In addition, some of the bearing rings have been silver coated. For the cage, a polymer material (PEEK) has been applied.

With the specific focus on applications in pointing systems and scientific instruments, the bearing performance in dry running condition (with and without silver coating) has been studied. For comparison, grease lubricated bearings have been tested as well.

After run-in and initial characterisation, the prototype bearings have been exposed to vibration testing within a dummy cartridge and to a reduced life test in thermal vacuum.

Application Fields:

The use of ceramic balls makes the bearings more inert against adverse effects like cold welding and adhesive wear.

Examples for potential applications can be found with:

- Pointing mechanisms for antennas, optical communication terminals and instrument heads;
- Space mechanisms for extreme temperature environments (high-temperature applications as well as cryogenic devices);
- Systems exposed to chemically aggressive media (e.g. in spacecraft propellant systems, or for liquid chemicals in space experiments).

Improvement to the state of the art:

The investigation has further substantiated the introduction of new materials in ball bearing technology for space use. By doing so, the bearing properties in critical areas such as resistance to stress corrosion cracking and long-term chemical degradation of lubricants due to reaction with bearing steels can be considerably improved. Furthermore, ceramic balls can be manufactured to very high surface quality standards, which has a positive impact on torque noise and lifetime. In this context, hybrid ceramic bearings appear very promising for critical applications like in pointing systems. In dry running condition, they reduce the risk of contamination, such as in the field of optics.

Achievements:

The general suitability of the selected bearing configuration for space applications has been demonstrated. Areas for further investigation comprise, among others, the long-term adherence of soft metal coatings acting as dry lubricants, and a further potential reduction of the bearing friction torque over extended lifetime.

Design of a miniature Electron Energy Analyser for Space Applications

Keywords: Smart Skin, Micro fabrication, Electron Energy, Analyser

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Company Point of Mr. T. Harper (e-mail: Tim@cmp-cientifica.com; phone ext. 7185; fax ext. 7186)

Name of Program: ARCoP
Year: 1999

Overview/Scope of the activity: The monitoring of the plasma environment and spacecraft charging is conventionally carried out with a dedicated instrument. This activity uses micro fabricated "smart skin" components built into the spacecraft's exterior to carry out such monitoring tasks. The objective of the contract is therefore the identification of a suitable design for that instrument.

Application Fields: The proposed design can be configured for many different applications to space missions, from monitoring of space weather to planetary exploration.

Improvement to the state of the art: Micro fabricated "smart skin" components should enable significantly reduced weight and power budgets, as well as economies of scale by virtue of potential mass-production.

Achievements: A general outline for the instrument design was completed with the help of simulations. This design contains a number of free parameters that need to be adjusted for the eventual flight configuration, but the results presented are very promising. A proposed design for a miniature electron energy analyser was modelled, and an optimum design found which gave an energy resolution of 20%, while being small and lightweight enough to be deployed in arrays over large areas of spacecraft surfaces.

Mini-Invasive Surgery Instrument

Keywords: Medicine, Surgery

Contractor: COMAT S.A.

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Company Point of Mr. J.L. Cartier (email: cartier@comat-aerospace.com; phone ext. 2616; fax ext. 5125)

Name of Program: ToT

Year: 1998

Overview/Scope of the activity: The objective of this project is to transfer the technology of a hinged wrist, mounted on a handling arm and taken on board of an automatic planet-exploring vehicle, to an endoscopic surgery application. The asset for the surgeon is the accuracy in which the instrument reproduces his gesture through a 10 mm diameter tube. These new ways of operating represent from 20% to 70% of the operations, depending on the pathology. Nevertheless the development of the existing instruments has not reached the level of the other surgery techniques such as video-optical instruments. The actual lack of handiness and precision would take good advantage of a miniaturization of the spatial technology.

Application Fields: Endoscopic surgery applications.

Improvement to the state of the art: Up to now, the existing instruments only have a few degrees of freedom available. Therefore, the surgeon wastes a lot of time with these instruments that do not give him all the required functions for the surgical operation. This new instrument will be able to allow all the functions that are available during an open surgery. It will reduce the time (i.e. the cost) of the operations while giving the surgeon better sensations, and mobility. The operating and maintenance costs will have to be as low as possible so as to find applications in the whole surgery environment.

Achievements: Prototype built by ONERA (F) and tested by CINTER of Toulouse. COMAT concluded to the non-feasibility of the concept, as even if operational on average size actuators, it appeared impossible to miniaturise.

Development of Thermostatic Transport Container for Scientific Needs

Keywords: Container, Thermostatic, Sample Transport, Laboratory Transport

Contractor: **COMAT S.A.**

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Web page:

Company Point of Mr. J.L. Cartier (email: cartier@comat-aerospace.com; phone ext. 2616; fax ext. 5125)

Name of Program: ToT

Year: 1999

Overview/Scope of the activity: The objective of the proposal is to design a Thermostatic Transport Container for scientific needs. The design concepts of this product, directly issued from the COTHERM (IBIS ground support) and FERTILE CTA (flight equipment), need to be adapted to a general use (not specifically space related) as well as for industrial production.

Application Fields: Transport biological samples (from sampling zone to laboratory or from laboratory to laboratory) and human organs for surgery.

Improvement to the state of the art: The following main qualities are sought: improved performance and autonomy; programming and recording capability; fitted for transport (shock proof, light weight and easy handling); square samples volume and easy maintainability (i.e. battery retrofit).

Achievements: The container has been built to withstand severe transport conditions, and its useful volume is approximately 5 litres. The internal temperature is settable between 4°C and 37°C by 0.1°C steps; internal batteries provide good autonomy - more than 20 hours for 6°C samples at 25°C ambient Temperature. The container is fitted with a graphic display and a keyboard. Internal Temperature setting and parameters reading are done through an icon style based interface. Internal and ambient Temperature as well as events and alarms of the last 30 days are recorded; these data can be either displayed as curves on the display or transmitted to a PC by a serial link. ESA bought 5 "thermocases" and CNES 4, for pre & post-flight bio samples transport. It was used during the last FOTON missions and SOYUZ taxi flights.

Report on Composites Industry for Support in Promotion of Use of Space Developed Composites

Keywords: Composites, Market, Technology Transfer, Trends

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Company Point of Mr. M. Palantera (email: markku.palantera@componeering.com)

Name of Program: ToT

Year: 2002

Overview/Scope of the activity: The aim of this activity is to produce a report which will help in the planning of composite related technology transfer activities. Componeering will undertake extensive market surveys and describe the current use and trends of composites in different fields of industry where they are widely used. The use of software tools in composite design will also be investigated, and the opportunities for technology transfer from the space industry to other European Industry will be identified.

Application Fields: To assist in technology development planning, and in selection of technology transfer programmes.

Improvement to the state of the art: This report will provide a broad and up-to-date picture of the state and direction of European use of composite technologies.

Achievements: The report by Componeering has been delivered and profiles the following industrial sectors:
Aircraft industry, Ground Transportation, Marine, Wind Energy, Construction and Infrastructure, Offshore Industry, Sporting Goods and Formula 1 Car Racing. The report has also reviewed the software tools available for composites design and identified some areas of opportunity for technology transfer, namely in exotic composite materials and in design, analysis and verification methods for composite structures.

Advanced Distributed Learning Technology: Feasibility Study for ESA programmes

Keywords: Learning, Distance Learning, Distributed Simulation, e-Learning, Training

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Company Point of Mr. A. Pieniazek (e-mail: info@d3group.com)

Name of Program: LET-SME

Year: 2000

**Overview/Scope
of the activity:**

The activity addressed several advanced technologies to enable distance learning and distributed simulation functionality, both for the sake of increasing the efficiency of proficiency training of a broad variety of experts such as aerospace engineers, astronaut candidates, training instructors, etc. Design and implementation of a software prototype of distributed learning system with a simulation integrated therein was the main scope of the activity.

Application Fields:

The study was focussed on a particular user domain, one of ESA payloads to be installed and operated onboard the Columbus Orbital Facility with ground support for such operations to be provided from ESA/ESTEC. In particular, the European Drawer Rack will be a payload to support a number of experiments aboard the International Space Station during a long period of time.

**Improvement to the
state of the art:**

Today, most learning and training material aerospace engineers and astronauts are provided with is implemented and used on a local basis. This results in significant overheads related to travel and accommodation. New information technologies allow for dramatic increase in efficiency of simulation, training systems and infrastructures by making possible remote and interactive connections between training sites. Using distributed learning the users could get a considerable amount of training remotely thus reducing overall costs.

Achievements:

The combined use of these 2 technologies has proved to be very beneficial in terms of efficiency, time, development and travel. One perspective used a case study related to the space station distributed payload training. Using distributed learning, the users could get remotely a considerable amount of training, thus decreasing overall costs of high-end simulations, reducing travels to get training and increasing effectiveness of work when on a mission in a remote location. A prototype of distributed learning system has been successfully designed and implemented. The prototype is under evaluation by different groups of users at ESA for a probable implementation of an operational system in a short term.

The system developed is accessible through <http://www.estec.esa.nl/adl>

Application of SMA's to ornamental stone splitting

Keywords: Shape Memory Alloy, SMA, Stone Splitting, Quarry

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Company Point of Ms. M. Primavori (e-mail: maura.primavori@dapollonia.it; phone ext. 8148; fax ext. 1078)

Name of Program: ToT

Year: 2000

Overview/Scope of the activity: The aim of the proposed work is to develop a compact and easy to use splitting system to extract high quality stone blocks in the quarries. The proposed system (SMAQ2) is based on the technology of the Shape Memory Alloys (SMAs) which are novel materials capable to return to a predetermined shape when heated, generating large forces and displacements. The project is focused on the identification of the system requirements, the design, manufacturing and testing of a prototype and on the establishment of a market implementation plan for such development.

Application Fields: SMAs were first used in aerospace applications. The proposer has investigated the application of SMAs to stone splitting achieving significant breakthroughs towards their cost-effective application in the quarrying sector.

Improvement to the state of the art: This novel system aims at overcoming the limited productivity, quality and safety performances of traditional techniques. Its targets are reducing the extraction costs, increasing the rates of production and operational performance of the quarry, having a long operative life and a low cost of implementation. An estimation of 30% of the European quarries adopting this technique would lead to an overall saving of about 70 MEuro/year.

Achievements: The results obtained within this project indicate that the developed device is capable to effectively split stone blocks and can be used as an efficient working tool of ornamental stones. The optimised design of the splitting apparatus and the manufactured prototypes (both metallic and plastic) are available as a result of the project, as well as test results.

Field Programmable Gate Array for Satellite Clouds Detection Equipment

Keywords: Clouds Detection, FPGA, Imaging, Very Fast / Real Time Image Processing, Earth Observation, DSP

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Company Point of Mr. P. Fillatreau (e-mail: p.fillatreau@delta-technologies.fr; phone ext. 900; fax ext. 901)

Name of Program: ARCoP

Year: 2000

Overview/Scope of the activity: The purpose of this study is to implement and validate on-board cloud detection software in a Field Programmable Gate Array (e.g. for storage optimisation of Earth Observation data).

Application Fields: On-board cloud detection may bring several improvements: of the image processing phenomenon; of meteorology forecasts; of satellites image acquisition programming; optimisation of on-board systems, etc.

Improvement to the state of the art: The main features of FPGA are the following, if compared with a microprocessor or DSP: processing times are reduced by a factor of 1010 if compared with DSP and 100 if compared with a standard microprocessor; architectures based on FPGA permit greater miniaturisation; FPGA architectures are programmable and they offer important advantages for use in space applications. On-board clouds detection may bring several improvements: of the image processing phenomenon; of meteorology forecasts; of satellites image acquisition programming; optimisation of on-board systems, etc.

Achievements: The final presentation took place with a successful demonstration of the cloud detection algorithm implemented on FPGA - an algorithm by of The Netherlands Royal Meteorological Institute (KNMI) - using a number of recent Meteosat images provided by KNMI. The results show that it is possible to implement cloud detection processing on a FPGA, and to achieve processing times approximately 100 times faster than on a PC. The technology can be used for other on-board or embedded processing algorithms.

GLOBE: Gas Lubricated Oil Bearings

Keywords: Lubrication, Bearings, Liquids, Microgravity, Friction

Contractor: DTM Technologies

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Company Point of Mr. F. Cassese (email: dtm@dtm.it)

Name of Program: INNOVATION

Year: 2000

**Overview/Scope
of the activity:**

The proposal aims at demonstrating a new technology emerged from programmes of fundamental research. The idea is to make liquids work as gas-lubricated bearings and as vibration isolators in microgravity, where the smallness of the loads bearable by surface tension is not too severe a limitation. This is interesting because non-coalescing and non-wetting liquids work with practically zero static friction. Their advantages could allow an unprecedented instrumental sensitivity and, maybe, the construction of devices without homologous conventional ones.

Application Fields:

Possible applications could include: attitude control, measurement of residual gravity, non-contact positioning, mechanical isolation of scientific packages, monitoring of anomalies in the terrestrial magnetic field, and detection of very weak forces in many other instances.

**Improvement to the
state of the art:**

These liquids, working with practically zero static friction, do not undergo wear, do not produce debris nor noise, do not require external sources of lubricant nor alignment procedures, and are not subject to torque. Moreover, they are able to work in perfect steady conditions, with very low power consumption, and have the unique ability to work as vibration isolators at the same time.

Achievements:

In the course of the activity, a breadboard model of the complete suspension model has been designed, built and tested. The breadboard model features a spherical payload body. Furthermore, it comprises four liquid drop suspension points in a tetrahedron configuration, including the complete infrastructure for fluid management & heating, launch locking etc. The basic functionality of the suspension system has been demonstrated using the breadboard model and a series of additional development tests. A next phase of the development should aim at the qualification of system towards a potential in-flight demonstration under real micro-gravity conditions.

High Milli-Kelvin Resolution Fibre Optic Temperature Sensor

Keywords: Temperature, Measurement, Sensor, Fibre Optic, Resolution, Milli-Kelvin

Contractor: EM Technology

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Web page: www.emtechnology.co.uk

Company Point of Mr. Beverley T Meggitt (e-mail: btmeggitt@emtechnology.co.uk)

Name of Program: ARCoP
Year: 1999

Overview/Scope of the activity: The purpose of this project is to reach high precision and long term stable measurements of temperatures. This activity is in two phases.
Phase I: to design, develop and evaluate a prototype-demonstrator in order to determine its ability to resolve to sub-mK temperature changes by use of polymer coatings to enhance the sensitivity of the grating sensor. The parameters of importance are minimum temperature resolution, temperature response time, unambiguous dynamic range / linearity and measurement stability of the system.
Phase II: to refine the technology for improved robustness and higher resolutions

Application Fields: Wide range of applications: the determination of thermal barrier coatings in aero-space engines, thermal profile across reacting semiconductor wafers, studies on the thermal bonding of rubbers and plastics, measurement of human tissue (including small temperature changes in human physiology -e.g. radiation induced, system is not affected by electromagnetic fields-) operative hypothermia & therapeutic hyperthermia, measurement of the effects of microwave heating within materials.

Improvement to the state of the art: Further progress towards the attainment of a sub milli-Kelvin temperature resolution sensor system. Up to now, very little work has been reported on Bragg grating use in measurement of temperature and none in high resolution thermometry. No equivalent temperature sensor product currently exists on the market with a comparable resolution performance.

Achievements: Phase I: The completed system was functionally tested and was shown to behave to the design requirements. However, a series of test showed that the sensor drift over a long period was up to >0.5°C. Remedies for improving the system performance -specially in terms of resolution- are suggested.
Phase II: A high power unpolarised ASE based Er-doped fluorescent fibre source was developed and incorporated, which eliminated the birefringence related measurement drift. A temperature compensated fibre reference grating structure was developed, which was shown to reduce the reference gratings temperature sensitivity by a factor of x5. A fringe-counting algorithm was developed which permitted the continuous tracking of phase over multiple fringe changes. The demonstrated performances represent an improvement of >x10 in response time, >x12 reduction in measurement drift and a factor of >x60 in unambiguous range.

Time Domain Multiplexed Fibre Optic Bragg Grating Strain Sensor System for the Integrity Monitoring of Space Structures

Keywords: Sensor, Sensor Arrays, Structures, Fibre Optic, Bragg Grating Strain, Wavelength Domain, WDM, OTDR, Structural Monitoring

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Web page: www.emtechnology.co.uk

Company Point of Mr. Beverley T Meggitt (e-mail: btmeggitt@emtechnology.co.uk)

Name of Program: LET-SME

Year: 2000

Overview/Scope of the activity: The purpose of this project is to use the current advances in fibre optic technologies for the development of distributed sensor systems that could be used for the structural monitoring and sensing of (space) structures. This includes the development and evaluation of a prototype-demonstrator in order to demonstrate its capability to monitor multi-strain sensor arrays.

Application Fields: Monitoring multiple sensor points on large engineering space structures.

Improvement to the state of the art: The innovation in technology being applied here is the novel combination of both OTDR and WDM techniques.

Achievements: Contract complete. A x 8 sensor with combined TDM and WDM multiplexing has been breadboarded and demonstrated. Its performance has also been measured. The strain resolution noise floor of the system is somewhat higher than expected, but the cause has been analysed and understood. The wavelength against strain tests showed a resolution of 1.3 pm with good linearity over a 1500 ue test range, and strains exceeding 1% strain should be detectable.

Green Hydrogen Peroxide Monopropellant Rocket Engine With Advanced Catalytic Beds

Keywords: Chemical Propulsion, H₂O₂, Monopropellant Thrusters, Catalytic Beds, Green Propellants

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Fax number: (+39) 0564 456315
Web page: N/A
Company Point of Dr. Leonardo Biagioni

Name of Program: LET-SME

Year: 2005

Overview/Scope of the activity:

The scope of the proposed work is to design and test the prototype of a hydrogen peroxide monopropellant thruster of low-medium thrust level (5-25 N), with particular interest in the development of a catalytic bed having good activity and c^* efficiency, able to sustain a large number of thermal cycles with acceptable performance degradation and resistance to poisoning.

The proposed work plan is based on the following guidelines:

1. Analyze the current technology scenario for identifying several potential candidates as advanced catalytic beds for hydrogen peroxide decomposition and perform an experimental analysis for selecting the most promising ones.
2. Design a small prototype of a hydrogen peroxide monopropellant engine where the selected advanced catalytic bed shall be integrated together with suitably designed propellant injection system, thrust chamber and exhaust nozzle.
3. Carry out the realization of the prototype and its experimental validation in order to determine its main propulsive parameters: decomposition temperature and efficiency, thrust and specific impulse, c^* efficiency, number and repeatability of short duration impulses, catalyst resistance to poisoning and thermal cycling.

Application Fields:

The characteristics of rocket engines using hydrogen peroxide make them particularly attractive for low and medium thrust space applications and, in particular, for LEO commercial or scientific satellites and for some interplanetary scientific missions. In these cases the requirement for a lower power level is driven by budget considerations, but the components are typically designed in order to obtain the best possible performance

Finally, it is worth noticing that liquid bipropellant rocket propulsion will also greatly benefit from the development of advanced HP catalytic beds, opening the way to the widespread application of hydrogen peroxide/hydrocarbon rocket engines.

Improvement to the state of the art:

The most important improvements to the present state-of-the-art in the design of hydrogen peroxide monopropellant thrusters will be related to the catalytic bed and the corresponding injection mechanism. With the aim to solve some of the most significant problems typically observed in past hydrogen peroxide thrusters, the objective is to find the optimum compromise between the resistance to poisoning and clogging, the minimization of the pressure losses, the avoidance of propellant flooding and flow channeling, and the attainment of adequate transient response and repeatability. These aspects impose conflicting and coupled limitations to the various characteristics of the catalytic bed, namely the bed length and cross-flow dimensions, packing, permeability, active surface area and flow pressure losses.

Achievements:

New OBS Modelling Technology

Keywords: Software, On-Board, OBS, Modelling

Contractor: **ESTEREL Technologies**

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Company Point of Mrs. S. Granier (sylvie.granier@esterel-technologies.com; phone number: +33 4 92 02 40 53)

Name of Program: LET-SME

Year: 1999

Overview/Scope of the activity: The goal of the contract was to model a part of the On-Board Software of an ESA satellite using a new behavioural modelling language called Esterel, to exercise it and its usefulness.

Application Fields: In space systems the proportion of sub-systems containing software is increasing continuously. More and more critical functions are implemented using software; consequently, the criticality of software failures is very high.

Improvement to the state of the art: Significant gain in software quality and development time for this application. The main advantages of ESTEREL are increased productivity and safety, more predictable system behaviour and reduced development delays.

Achievements: The case study was specified, modelled in Esterel and then verified with the Esterel toolset. The activity allowed to understand the real-time semantic of the language. Esterel is synchronous, a characteristic that simplifies verification significantly, and as such is successfully used in military aircrafts whose bus architecture is cyclic.

Fast Damage Assessment after major Natural Disasters

Keywords: Images, Space Imagery, Satellite, Natural Disaster, Damage, Assessment, Relief, Map, Mapping

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Fax number: (+ 33) 01 46 64 61 61

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Company Point of Mr. R. Guillande (e-mail: rg-gsc@wanadoo.fr)

Name of Program: ARCoP
Year: 1999

Overview/Scope of the activity: The objective of this study is to specify the products and services based on EO data which may be offered today to Civil Protection authorities for fast (within 1 or 2 days) damage assessment after a major natural or industrial disaster, depending on type and condition of its occurrence (geography, socio-economics, etc.). It will include the exploitation of any available satellite images to provide damage assessment maps for relief operations and global monitoring of the disaster intensity.

Application Fields: Satellite images for use on the field to propose a fast damage assessment service to Civil Protection agencies and humanitarian operators.

Improvement to the state of the art: The innovation will reside in the ability to provide specific products (damage maps, accessibility maps, environmental impact) from any space sensor, on any kind of major natural disaster, in very short time after the event and adapted to users such as Civil Protections, NGO's and any operators providing field rescue or relief activities.

Achievements: Following a survey of potential user organisations, a set of Earth Observation (EO) data parameters was established. A review was then provided of the ability of current EO sensors to measure these parameters, and included 3 cases where the data were evaluated in a dedicated GIS environment. This study has provided ESA with information detailing the expectations of the EO community, the usefulness of EO data and products, and a self standing Geographic Information Service kit. This has served to highlight the value of endeavour such the International Charter on Space and Major Disasters, and raised the need for a standardized scale of disaster ranking and evaluation.

PARIS Interferometric Processor Analysis and Experiment Results (PIPAER)

Keywords: Interferometry, Interferometric Processor, GNSS, GPS, Navigation, Signal, Remote Sensing, Altimetry, Carrier Phase

Contractor: **GMV S.A. Grupo de Mecánica del Vuelo**

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Company Point of Mr. J.B. Serrano (e-mail: jbserrano@gmv.es; phone ext. 2100; fax ext. 2199)

Name of Program: ARCoP

Year: 1999

Overview/Scope of the activity: The utilisation of Guidance and Navigation Satellite Systems (GNSS) and Global Positioning System (GPS) signals for purposes other than navigation is gaining importance nowadays. The goal of the proposed work is to use the phase information of the reflected signal from a PARIS GNSS system for altimetric purposes. In particular, the possibility of using the phase from a dual frequency GNSS system interferometrically will be studied.

Application Fields: Interferometric processor. Its objective is to achieve better accuracy in the fields of ocean altimetry, ocean roughness observations and wind over ocean scatterometry.

Improvement to the state of the art: The advantage of the use of GNSS signals for these new purposes is that typically very expensive methods are used, while the hardware required in the GNSS case is cheap and it is easy to assess global coverage.

Achievements: The performed work was composed of a theoretical part and an experimental one. Theoretical results indicate that the concept works for oceans with very small roughness. Concerning the experimental part, two main tasks have been faced: water height evolution determination -these data have been successfully processed showing centimetre accuracy in surface height estimations for small roughness water surface- and carrier phase measurements extraction from recorded high-speed I/Q RF measurements. The confirmed possibility of obtaining Carrier Phase measurements from high-speed recorded Radio Frequency data in open loop will help the realisation of future experiments with rougher sea surfaces.

Validation and Developments of Integrated Plasma and Fluid Dynamics Solvers

Keywords: active flow control using magnetic fields, plasma actuators, plasma waves and their numerical solution, MHD code validation

Contractor: **HPCC-Space GmbH (prime) (formerly CLE GmbH; DIA, University of Pisa; DIE, University of Bologna)**

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Company Point of Dr. Jochem Hauser (email: jh@hpcc-space.de)

Name of Program: LET-SME

Year: 2005

Overview/Scope of the activity: Plasma flow devices for shielding of external or internal high-speed flows utilizing magnetic fields are of great importance in the design of future entry and re-entry vehicles. At the same time, magnetogasdynamic simulation software able to handle strong magnetic fields for high speed flows and complex geometries is necessary for this activity but yet not at the disposal of the European space community: the purpose of the proposed activity is therefore to design and deliver the first version of such a code, with a strong efforts towards validation with new experimental MHD/plasma data.

Application Fields: Simulation tools for drag reduction using ionization and magnetic fields as well as heat flux reduction of space vehicles. Design of active flow control using plasma actuators.

Improvement to the state of the art: Providing a simulation tool for complex 2D geometries coupling the Navier-Stokes equations with the Maxwell equations and validating the software with respect to experimental data and testcases from the literature

Achievements: The Project was successfully completed. A two-dimensional MHD simulation code was delivered together with a database for MHD simulations. The three-dimensional experiments from Alta S.p.A. were numerically rebuilt. It was shown that the shock-standoff distance could be increased by 8% for weakly ionized flows. Lessons learned in combination with an assessment of the technical potential of MHD.

Study on Control of Structural Deformations

Keywords: Structural Deformations, Telescopes, Smart Structures, MIMO controller, Sensing and Actuating Devices

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Company Point of Mr. Ernst K. Pfeiffer (e-mail: pfeiffer@hps-gmbh.com; phone ext. -90; fax ext. -99)

Name of Program: LET-SME

Year: 2001

Overview/Scope of the activity:

The source of structural deformations of an operating telescope in orbit is mainly the thermal environment it is subjected to. These deformations lead to a shift and a change in position of the optical elements resulting in misalignment and a decrease of performance. The proposed activity is focused on the improvement of alignment stability, pointing accuracy, deformation control and thus of optical performance of telescope structures operating under orbital environmental conditions. This objective shall be reached by application of smart structure technology characterized by the use of sensing and actuating devices, which are integrated in the structure and coupled to a closed MIMO controller.

Application Fields:

Future space missions, which will focus on the observation of planets like the Earth, will be based on high resolution antennas and telescope structures. The stringent requirements of these structures are limited by the environmental conditions in space. Changing thermal conditions could cause inadmissible expansions. HPS proposes a new approach with new multi-functional materials (e.g.: PZST, shape memory alloys or special polymers) and other improvements to the state of the art aimed at improving the performance of these structures.

Improvement to the state of the art:

This innovative step in structural deformations control technology promises the following benefits: improvement of optical performance in terms of alignment accuracy and reduced vignetting; enhancement of operational phases of space telescopes; elimination of disturbances in the very early time of formation; mass saving; lifetime critical and mass adding secondary mirror drives can be made obsolete; and material selection of the structure can be done under optimum mechanical performance aspects.

Achievements:

The performance analysis has identified a maximum free stroke of the tripod of 30 μm . That stroke is analogous to the deflection of the tripod head when applying a mass of 100 kg, representative for typical in-orbit thermo-mechanical loads. A respective analysis has confirmed the possible structural deflection compensation. Beside the achieved performance, a high learning curve concerning manufacturing technology was achieved. The embedding of piezo patches and such highly piezoelectric fibres is a very critical task, but could be solved by the collaboration of several SME-companies and R&Ds, each very experienced in their field. Such collaboration will also help in the future to develop high end technology to be applied as part of large space systems.

Study for the Development of a Compact, Vibration-Controlled Telescope Arm

Keywords: Ultralightweight, Structure, Telescope, Mast, Adaptronic, Piezoactuator, Boom, Ceramic Actuators, Adaptronics

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Company Point of Mr. Ernst K. Pfeiffer (e-mail: pfeiffer@hps-gmbh.com; phone ext. -90; fax ext. -99)

Name of Program: LET-SME

Year: 2001

Overview/Scope of the activity: The goal of the proposal is the development of a compact, lightweight, vibration-controlled telescopic mast. The technology is based on a satellite-supported mast and deployment system for solar sails which has to be modified for further space projects. In addition to necessary structural changes, measures to reduce vibrations are to be taken into consideration by integrating adaptronic systems. The study will demonstrate deployment and storage of the mast system, proof of adaptative vibration reduction properties of the adaptronic system and performance of tests with different loads.

Application Fields: The telescope mast system can be used for various extra-terrestrial applications. After the necessary modifications, this technology will be available for space projects such as Solar Arrays and Large Deployable Reflectors.

Improvement to the state of the art: Although the use of piezoactuators in basic panel structures to address vibration compensations is being studied by ESA, the use on long flexible booms is of interest, in particular in view of the possible demonstration flight and future development of large in-orbit deployed solar sails and the planned development of flexible solar arrays. The improvement refers mainly to the implementation of piezoceramics onto CFRP structures, to the damping of ultralight structures and to the ultralight CFRP structure itself.

Achievements: The maximum theoretical damping for a 20m boom using chosen control strategy was 4.5%. Test results show effectiveness of adaptive control on ultra-light space structures; maximum damping of demonstrator was 1.8% using PPF control. Only qualitative transferability of experimental results on technology demonstrator to adaptive vibration control of original 20m boom has been possible.

Airborne Testing of Model of Smart Camera with Optical Correlator

Keywords: Camera, Imaging, Optics, OFP, Attitude Control, Sensor

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Company Point of Mr. K. Seifart (e-mail: seifart@htsdd.de; phone ext. 77560; fax ext. 775611)

Name of Program: LET-SME

Year: 2001

Overview/Scope of the activity: Pushbroom scan systems have many advantages over area scanning cameras, but require a high uniformity of the image motion in the focal plane, which implies high requirements to the attitude control of the spacecraft. To solve this problem, it was proposed to use the onboard Optical Fourier Processor (OFP) for recording the image motion in the focal plane of the camera by the matching of the sequential images from two additional area sensors. The main objectives of this project are to design and manufacture an imaging system (camera) breadboard, to carry out the hard- and software update of the existing model of the OFP, to develop and assemble a satellite motion simulator and to integrate tests of the camera and OFP with satellite motion simulator.

Application Fields: Practical implementation of the proposed solution will help to reduce the cost of observation missions to Earth and other planets and to improve the quality of the obtained images. It will allow expansion of the area of pushbroom scanner application to satellites with moderately attitude stability, micro satellites or to use them as secondary imaging payload for low orbit communication satellites or the Space Station.

Improvement to the state of the art: This project aims at reducing the satellite stability requirements for imaging payloads, which is very important for planetary missions.

Achievements: In the three research projects (1999-2002) the feasibility of the concept of the Smart Pushbroom Scan Imaging System (SmartScan) has been demonstrated and expected performances for a spaceborne system have been estimated. Pushbroom satellite imagers are sensitive to attitude instability, which results in image distortions. Within the SmartScan imaging system these distortions are corrected a posteriori on base of a real time record of the focal plane image motion, made with auxiliary focal plane image sensors and an onboard optical processor. This allows high quality imaging with a pushbroom image sensor from satellites with only moderate attitude stability.

Real Time Intelligent Camera Breadboard with Optical Fourier Processor

Keywords: Camera, Imaging, Optics, OFP, Attitude Control, Sensor

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Name of Program: LET-SME

Year: 2000

Overview/Scope of the activity: Pushbroom scan systems have many advantages over area scanning cameras, but require a high uniformity of the image motion in the focal plane, which implies high requirements to the attitude control of the spacecraft. To solve this problem, it was proposed to use the onboard Optical Fourier Processor (OFP) for recording the image motion in the focal plane of the camera by the matching of the sequential images from two additional area sensors. The main objectives of this project are to design and manufacture an imaging system (camera) breadboard, to carry out the hard- and software update of the existing model of the OFP, to develop and assemble a satellite motion simulator and to integrate tests of the camera and OFP with satellite motion simulator.

Application Fields: Practical implementation of the proposed solution will help to reduce the cost of observation missions to Earth and other planets and to improve the quality of the obtained images.

Improvement to the state of the art: This project aims at reducing the satellite stability requirements for imaging payloads, which is very important for planetary missions.

Achievements: Detailed design has been developed of the mechanics and the correlator electronics, manufacturing, integration, and software routine for development and testing. The Breadboard has been designed and manufactured to allow an airborne verification of this concept.

Non-intrusive Telemetry Acquisition System for Engineering Purposes

Keywords: Telemetry Acquisition, Non Intrusive, Monitoring Systems, Miniaturisation

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Fax number: (+ 39) 06 439 3828

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Company Point of Mr. M. Perelli (e-mail: imtsrl@imtsrl.it; fax ext. 34)

Name of Program: LET-SME

Year: 2001

**Overview/Scope
of the activity:**

This development aims at fulfilling, in a cost-conscious approach, the well known problem to the space engineers of disposing, timely, of visual data concerning the behaviour of certain devices deployed and operated in space, for which conventional telemetry alone cannot provide all answers necessary to solve the unknowns associated to the environment. Accordingly, miniaturised visual telemetry system was developed and demonstrated, which can be used on board space vehicles either for monitoring fixed objects or to monitor the evolution in time or space of objects on board satellites or other space objects. The system is constituted by a microcamera mounted on a miniaturised two-axis micropedestal.

Application Fields:

Typically, since vision is the most powerful sensory element, a non-intrusive telemetry device takes the form of a camera. The availability of low-cost, repointable, non-intrusive telemetry acquisition systems for engineering purposes is a powerful tool that will be of great help to the aerospace engineers, because of the flexibility it will provide in early phases of in-orbit tests and demonstrations of new devices, circuits and systems.

**Improvement to the
state of the art:**

The innovations of the proposed architecture consist in the following: the use of a highly miniaturised 2-axis pedestal, capable of carrying a microcamera, characterised by a target mass of less than 100 g; the use of CMOS detectors in the visual band imaging arrays, and of thermopiles for the IR band imaging arrays; a clever use of COTS microcircuits at UHF for wireless data transmission over distances up to 50-100 m; a clever use of data compression in the sensing head equipped with a visual camera to reduce the transmission datarates; and a miniaturisation enabling reaching a mass of the sensing head of less than 100 g, and of the DAU of less than 200 g.

Achievements:

The project has been finished successfully and on time. It has shown the feasibility of a non-intrusive telemetry acquisition system for engineering purposes and has allowed the identification of possible uses and future needs. The project has been completed within the required time frame and has achieved the required specifications. Nevertheless, several future needs and outlooks have been identified: - miniaturisation of existing electronics, adding a VHF receiver for telecommands, an S-band forward link for relay of real time video, a real time compressor in hardware, incorporation of a thermal IR sensor, and addition of a variable zoom.

Alternative Rigidization Method for Inflatable Structures (ARMIS)

Keywords: Gossamer, rigidisation, inflatable, thermoplastic

Contractor: Inasmet

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Company Point of Alberto Lázaro (alazaro@inasmet.es)

Name of Program: LET-SME

Year: 2004

Overview/Scope of the activity:

As defined in space inflatable terms, rigidisable materials are materials that are initially flexible to facilitate inflation or deployment, and become rigid when exposed to an external influence. Thermally rigidised thermoset composites and Ultra-Violet rigidised composites are methods that have been widely studied, being the last method the one that has been more developed in recent years. The aim of the proposed work is to conduct further research in passive cooled thermoplastic composites, as an alternative to processes based on chemical rigidisation. In the last phase of the project, a breadboard for a solar array based on thin film solar cells, supported by inflated and passive cooling rigidising booms will be manufactured and tested.

Application Fields:

Inflatable components made of rigidisable materials may be used for a variety of space applications, from solar sails to sunshields, solar arrays, antenna and radars, mirror/optics, and habitats.

Improvement to the state of the art:

Between different rigidizing methods, passive cooling of thermoplastic composites has been selected for further research, mainly due to long storage life of materials, low outgassing, predictable and controlled rigidisation by embedded heaters, process reversibility, and no compatibility problem with membrane material (like transparency needed in Ultra-Violet curing).

Achievements:

The achievements obtained:

- A complete demonstrator for deployable solar cells (mesh-boom) based on gossamer structure was done.
- Flight Specifications and uses were obtained from EADS ST and used to make a compatible interface, and for the simulation-analysis model to define the lay-up of the boom and subsystems.
- A deployment mechanism was developed since EADS ST didn't provide the previously selected
- The specifications : rigidisation, bending, mechanical properties, outgassing and others were tested.
- Functional operations on/off deployment was carried out ; for this purpose specific testing bench was manufactured and assembly
- A new material for subTg curing process was developed based on a European source (SME)
- Deployable thin film Solar cells were demonstrated its manufacturability on flexible substrates. Nevertheless the efficiency of such solar cells still is low.
- Spin-off of this technology for terrestrial (houses) on thin-film substrate

Ceramic Materials Transfer

Keywords: Ceramic, Materials, Break Rings, Steel Casting, Boron Nitride

Contractor: Inasmet

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Company Point of Mr. M. Gutiérrez (e-mail: mguti@inasmet.es; phone ext. 622; fax ext. 560)

Name of Program: ToT

Year: 1999

Overview/Scope of the activity:

INASMET has developed an advanced ceramic material containing a mix of boron nitride and silicon dioxide to be used in an electric propulsion thruster. A formal agreement between Olarra (the main stainless steel manufacturer in Spain) and INASMET has been established for the transfer program proposal. Olarra will contribute to the project cost and offers the possibilities of testing on line the ceramic materials developed. If the feasibility study ends with successful results a procurement agreement between INASMET and Olarra for ceramics production industrialisation will be established.

Application Fields:

This material has very high resistance to thermal shocks, good insulation properties at high temperatures, low sputtering yield and high wear and temperature resistance. These features make it very useful in the fabrication of break rings for casting of steel, as well as at the copper and glass industries.

Improvement to the state of the art:

The tendency in industry is now to replace conventional oxide refractories with non oxide ceramics having excellent mechanical and thermal properties as new processes and alloys are developed. This transfer of technology will improve the performances of break rings, improving their reliability and reducing their cost by implementing a new Boron Nitride ceramic material in horizontal steel casting parts.

Achievements:

According to the on line tests in Olarra, it can be said that the technology developed for the electric propulsion thruster has found a promising application in the break rings manufacturing. The Break Rings were recuperated without cracks from the on line test at Olarra. Chemical attack has been low and machining marks were still observed in the external side of the Break Rings, though an important mechanical erosion has been observed in the corners of the Break Rings. More tests and more time in the casting process is necessary to confirm these promising results.

Development of Competitive High Performance Electronic Packaging & PCB Components made of Al Matrix Composites

Keywords: Electronics, Packaging, PCB, Materials, Composites, MMIC

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Company Point of Mr. M. Gutiérrez (e-mail: mguti@inasmet.es; phone ext. 622; fax ext. 560)

Name of Program: INNOVATION

Year: 2000

Overview/Scope of the activity:

The product line comprises a broad range of different electronic packaging cases for electronic devices used in space applications. Within this R&D programme, high content silicon carbide particles reinforced aluminium matrix composites (AMCs) were investigated. The major aim was to develop a high efficiency and price competitive manufacturing process and establishing a European source for the space industry.

Application Fields:

The standard metallic material used in casings for Monolithic Microwave Integrated Circuits (MMICs) and hybrids is Kovar, with has a much higher density and lower heat conductivity to remove heat from electronic components than the new materials proposed. The main electronic packaging applications are printed circuit boards (PCBs) and encapsulates for MMICs. However a broad range of electronic components for thermal management of electronic devices are also potential applications for the high content silicon carbide particles reinforced aluminium matrix composites intended to be developed under the frame of this R&D programme.

Improvement to the state of the art:

AMCs combine the positive properties of both aluminium and silicon carbide materials in order to obtain low weight, high heat conductivity, low thermal expansion, higher stiffness and strength to failure at high temperatures. These new AMCs will be more competitive, in terms of performance/price ratio, in comparison with same materials presently commercialised due to the low cost raw materials and the high productivity shaping technologies planned to be used.

Achievements:

During the course of this activity several critical aspects have been solved in order to produce the first packaging prototypes. The major achievements can be summarized with the identification of a raw material source within Europe, the development of a cost efficient manufacturing process for obtaining the basic packaging case, and finally the establishment of the workmanship procedures for meeting the final tolerance requirements.

Alternative Rigidization Method for Inflatable Structures (ARMIS)

Keywords: Gossamer, rigidisation, inflatable, thermoplastic

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Company Point of Alberto Lázaro (alazaro@inasmet.es)

Name of Program: LET-SME

Year: 2004

Overview/Scope of the activity:

As defined in space inflatable terms, rigidisable materials are materials that are initially flexible to facilitate inflation or deployment, and become rigid when exposed to an external influence. Thermally rigidised thermoset composites and Ultra-Violet rigidised composites are methods that have been widely studied, being the last method the one that has been more developed in recent years. The aim of the proposed work is to conduct further research in passive cooled thermoplastic composites, as an alternative to processes based on chemical rigidisation.

In the last phase of the project, a breadboard for a solar array based on thin film solar cells, supported by inflated and passive cooling rigidising booms will be manufactured and tested.

Application Fields:

Inflatable components made of rigidisable materials may be used for a variety of space applications, from solar sails to sunshields, solar arrays, antenna and radars, mirror/optics, and habitats.

Improvement to the State of the Art:

Between different rigidizing methods, passive cooling of thermoplastic composites has been selected for further research, mainly due to long storage life of materials, low outgassing, predictable and controlled rigidisation by embedded heaters, process reversibility, and no compatibility problem with membrane material (like transparency needed in Ultra-Violet curing).

Achievements:

The achievements obtained:

- A complete demonstrator for deployable solar cells (mesh-boom) based on gossamer structure was done.
- Flight Specifications and uses were obtained from EADS ST and used to make a compatible interface, and for the simulation-analysis model to define the lay-up of the boom and subsystems.
- A deployment mechanism was developed since EADS ST didn't provide the previously selected
- The specifications: rigidisation, bending, mechanical properties, outgassing and others were tested.
- Functional operations on/off deployment was carried out ; for this purpose specific testing bench was manufactured and assembly
- A new material for subTg curing process was developed based on a European source (SME)
- Deployable thin film Solar cells were demonstrated its manufacturability on flexible substrates. Nevertheless the efficiency of such solar cells still is low.
- Spin-off of this technology for terrestrial (houses) on thin-film substrate

Development and verification of a predictive model and engineering software guide for durability evaluation of polymer-based materials in LEO

Keywords: Materials, Polymer-based, Durability, Degradation, Erosion, Predictive Software

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Company Point of Mr. Z. Iskanderova (e-mail: ziskanderova@itlinc.com)

Name of Program: LET-SME

Year: 2000

Overview/Scope of the activity: The main objective of the proposed project is to develop a Predictive Erosion Resistance Software package that will serve as the first prototype of a comprehensive Engineering Guide for quantitative prediction and evaluation of polymer-based space materials durability and performance in LEO environment for spacecraft and space structure applications.

Application Fields: The proposed study will result in predictive material degradation software with a large potential for engineering and material selection usage, with direct applications in materials exposed to Low Earth Orbit.

Improvement to the state of the art: The proposed work is innovative in nature, because no well-established mechanisms or theories exist at the present time capable of predicting quantitatively the erosion rate and durability of carbon- and polymer-based materials in space environment.

Achievements: The development of the models of interaction of polymeric and carbon-based materials with LEO space environment was completed. The software design, implementation of four major approaches to materials durability evaluation in LEO, as well as major databases and graphics was completed within the time-designated milestones. The software architecture and design allows performing the predictive durability evaluation for more than 50 materials that are in the dictionary, but also allows to perform predictive durability evaluations for various polymeric or carbon-based materials by entering their chemical composition and structure. The ground based testing and evaluation of 40 materials was also executed.

Engineering Tool for Qualification of Optical Coatings

Keywords: air-vacuum transition, porosity, test equipment, optical coating qualification for Space

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Company Point of Dr Arun Roy (Technical), Director, author of the Proposal
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Name of Program: LET-SME

Year: 2005

Overview/Scope of the activity: The scope of the activity is to study and develop a standard methodology to test the behaviour of the optical coating during the transition vacuum to air and vice versa.

Application Fields: Space optical systems.

Improvement to the State of the Art: This proposal outlines the development of an Engineering Tool, which will:

- Acquire precision measurement of porosity factor 'q' and thermal coefficient 'α' of Optical thin film coating materials in-situ and in real time during both the vacuum fabrication phase and the vacuum - to - air stabilization phase of the thin-film multilayer structure.
- Model, predict and control the spectral changes of optical coatings during the vacuum to air stabilization process.
- Enable the manufacture of precision coated optics for space applications free from spectral and mechanical distortions, wavelength shift, environmental instability, delaminations etc, currently consequent upon the transition from vacuum to air.
- Enable in cryogenic vacuum the investigation of thermal cycling, delamination, stress and outgassing properties of coated optics.

Achievements: All the four aspects mentioned above been implemented and verified by means of designing, fabricating and testing the performance of both a very narrow band filter with sharp spectral edges and a NIR dichroic filter. The Engineering tool from this project is currently being converted to a fully fledged test facility for the qualification of Optical Coatings in relation to air-vacuum (ie Ground to Space transition) stabilization properties. The filter design and process monitoring software developed in this project is fully utilizable for the optimum design of vacuum stable multilayered optical coatings.

Innovative Internet Portal for Electromagnetic Design

Keywords: Internet, WEB Portal, JAVA, FEST2, Internet Application Service

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Name of Program: INNOVATION

Year: 2001

**Overview/Scope
of the activity:**

The Internet Application Service Provider (ASP) mechanism is the solution to satisfy user and industry requirements on electromagnetic design. Using this innovative IT technology, it is possible to connect interactively the electromagnetic designer to remote software design tools using a standard Internet Browser. In this frame, a dedicated and interactive Internet Portal using ASP and Java™ Technology, named eDesign, shall provide design services to engineers in order to lower design costs and reduce the overall time to market. The eDesign project objective is the development and publication over Internet of an innovative and interactive Internet Portal.

Application Fields:

eDesign is expected to demonstrate 2 major benefits to European Microwave and Millimetre Circuit designers:

1. The feasibility of a remote design supplied via Internet using a Design Portal covering the existing gap in remote usage of design software tools;
2. The easy spread of ESA FEST software in order to provide a dedicated design capability all over Europe with reduced costs and efforts if compared with the traditional local installation.

**Improvement to the
state of the art:**

For the first time, software design tools (e.g. ESTEC RF simulation software tool FEST2) and related useful information are provided remotely to the design engineer.

Achievements:

An Internet Portal has been created offering a dedicated workbench where users can access remote design tools and manage them as local ones. The existing technical difficulties, due to the complex interaction requirements, large data exchange, security aspects, etc. have been analysed and solved by using the newest IT technologies in the frame of Internet ASP approach. The eDesign portal has been tested using electromagnetic design of Millimetre-wave and Microwave Circuits. eDesign is also able to provide, by standard Browser navigation, information related to MMC design activities such as latest techniques involved, interesting papers presented in conferences, etc. by linking other already existing sites, etc. The approach is also open to support other design applications such as thermal, acoustic, Etc.

Sensor Network for Intelligent Monitoring of Space Systems

Keywords: Sensor, Monitoring, Fiber Optics, Bragg Grating, Failure, MTBF, Safety

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Company Point of Dr. Peter Hofmann (e-mail: peter.hofmann@kayser-threde.de; phone ext. 211; fax ext. 104)

Name of Program: LET-SME
Year: 2000

Overview/Scope of the activity: The main objective of this proposal is the provision of a Fibre Optic Sensor with Bragg Gratings as a means to monitor all relevant structural and thermal load impacts on space structures in advance of a catastrophic failure. This proposed system additionally includes gas concentration measurements for crew health and safety during medium to long-duration missions.

Application Fields: The demand for space system reusability and long-term application impose higher requirements on reliability and safety. Therefore, future space systems will require means to detect erroneous conditions before a critical condition can emerge. This system enables simultaneous and multiplexed monitoring of all relevant structural and thermal load impacts on space structures by measuring some key parameters.

Improvement to the state of the art: The principal improvement on the existing baseline instrument is the evolution from a stationery system with a long response time to fully dynamic Fibre Optic Sensors with Bragg Gratings enabling vibration measurements up to 200 Hz, which should have excellent strain and temperature resolution. This takes existing technologies and prepares them for use in a new space environment.

Achievements: The success of this approach was demonstrated during the course of the project by the award of a contract to supply such a Fibre-Optic sensor system into a modern Zeppelin, with very stringent requirements which more or less mandated an electrically inert sensor system. All the parameters of measurement ranges, the sample rates and the operational environment requirements proposed have been achieved. For strain sensing the new system has achieved a dynamic range sensitivity of 10 to 1500 microstrain with a resolution of 25 microstrain. And for temperature sensing applications the range is -25 to +175 °C with a resolution of +/- 0.5 K. The current work has improved the performance of the original concept by increasing the number of possible measurement points from 12 to 48 and the sampling rate from 1 to 1000 Hz.

Scanning Probe Microscopy for Bio & Nanotechnology onboard ISS

Keywords: Scanning Tunnel Microscope, Microscopy, Material Science, ISS, Nanotechnology

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Name of Program: INNOVATION

Year: 2001

Overview/Scope of the activity: The manufacturing and assembly of a Scanning Tunnel Microscope breadboard model which accounts for the relevant constraints imposed by in-orbit use aboard the International Space Station.

Application Fields: Micro-Nanotechnology - This activity presents a tool for investigation of weak interaction/forces in material science and Biology, with possible applications for in-orbit research.

Improvement to the state of the art: No Scanning Tunnel Microscopes for space station research have been developed so far. This activity places an emphasis on robustness, operability under reduced gravity and easy handling.

Achievements: An exemplary Scanning Tunnel Microscope breadboard model has been created, taking into account reduced gravity relevant constraints, with easy-to use user Interface.

FDEarth Project

Keywords: Processing Unit, Parallel Processing, FGPA, Fire Detection, Oil Slick Detection, Infrared Images, Optical Images

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Company Point of Contact Mr. P. Colandrea (email: pcolandrea@kell.it)

Name of Program: LET-SME

Year: 2001

Overview/Scope of the activity:

This project proposes the realisation of a dedicated processing unit breadboard (HW and SW) to process on board optical and infrared data in order to detect the presence and location of natural hazards. It should be able to perform "heavy" scientific calculus despite its small dimensions and low power dissipation. Nowadays, EO monitoring foresee off-line distribution of processed data derived from polar orbiting satellites. Continuous monitoring is achieved by geostationary satellites that can provide real time images of the whole globe but at poor spatial resolution. In both cases, an improvement going towards the realization of real time alarm services may be provided by on board "application processing". This solution is also useful to reduce data flow from satellite and relative bandwidth. The idea of FDEarth demonstration is to overcome the ground segment processing and to carry on board the part of a processing chain devoted to hazard identification. This has been achieved by designing and developing a dedicated HW breadboard based on FPGA. Configuration SW is such to allow parallel processing. Recognition has been based on a global parallel optimizer. The same parallel structure has been exploited to perform also other kind of image processing, i.e. SVD for lossy image compression.

Application Fields:

Detection of the presence and the location of fire on the observed scene. In particular, the infrared image makes possible to detect locations of unusual high temperature (that is, locations of fire), while the optical image makes possible to detect the location of the smoke generated by the fire. The same approach has been applied to detection of Oil Slick in VV/HH multipolarimetric SAR focused images.

Improvement to the state of the art:

The infrared and optical data are complementary as they put in evidence different aspects of the fire phenomenon (i.e. high temperature and smoke). This complementarity used properly can greatly improve the reliability of the fire detection. The on-board fire processing unit will be based on parallel calculus architecture; this will ensure fast processing of the remotely sensed data. The availability of an on-board fire processing unit, together with a reliable fire detection algorithm could be the base of a satellite based fire alarm service.

Achievements:

The machine and the SW has been finally assembled and test activities for both fire detection, oil slicks detection and image SVD is being completed. A report synthesising all the achievements of the activity will be produced for the project final review (see CCN1).

Enhanced Autotracking Unit for Telescopes and Antennas Definition Study

Keywords: Autotracking, Telescope, Antenna, Communication, Pointing, Transmission, Telecommunications

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Company Point of Dr. A. Valenzuela (e-mail: arnoldo.valenzuela@media-lario.it; phone ext. 139)

Name of Program: ToT

Year: 2000

Overview/Scope of the activity: The work proposed is aimed to the optical and mechanical development of a unit for high rate point-to-point communication system. Before any synchronisation or data transmission can occur in a communication system it is of course necessary that the transmitted field power actually reaches the receiver. The problems associated with pointing, acquiring and tracking a transmitted field are particularly acute when dealing with fields having extremely narrow beamwidth and long propagation distances.

Application Fields: The basic application of the autotracking subsystem is in telecommunications systems where the relative pointing between two units is one of the critical issues that governs the links performances.

Improvement to the state of the art: In the ground based communication field, the radio frequency systems can be used at a rate up to some hundreds of Mbps. New very high data rate optical communication systems based on the DWDM modulation technology are opening new ways of data transmission at rates in the order of 10 Gbps. The characteristics requested are basically concentrate in size, lightweight autonomous operation and reliability.

Achievements: The tracking algorithm has been proved to be effective during both scanning and tracking. Tracking stability is limited only by high level of scintillation. The present maximum tracking speed is limited to about 10 $\mu\text{m/s}$ by motor performances. Such speed is enough to recover building oscillations and thermal instabilities. The PC interface allows the user to remotely command and monitor the whole system and its operating behaviour.

Light-Weight Communication Terminals for Inter-Satellite Links Using Electro-Formed Nickel Telescopes

Keywords: Communication, Terminals, Satellite Links, Telescopes, LCT, Signals

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Name of Program: LET-SME

Year: 2002

Overview/Scope of the activity:

Within a previous contract, called "Feasibility Study for Light-Weight Communication Telescopes", Media Lario investigated and preliminarily designed a new approach for the realisation of inter-satellite laser communication terminals (LCT). The objective of this proposal is to demonstrate the functionality of a new proposed architecture with respect to the optical head including fibre coupling and transmission of communication signals, and to prepare the basis for the development and qualification of a light-weight, transparent, high speed optical inter-satellite link terminal suitable for series production, to be introduced in the satellite telecommunication market, at an affordable price.

Application Fields:

Free space optical terminals for the transmission and reception of laser signals at very high data rate (max. 2.5 Gbit/s per channel). The optical quality telescopes are produced in electroformed Nickel as a spin-off of the XMM X-ray technology. This replication process for the telescopes and the use of the fibre-optics technology will allow the commercialisation of high performance terminals at very competitive prices. These terminals have applications in short range links such as inter-satellite (including the International Space Station), satellite to ground, aircraft to aircraft, and aircraft to ground.

Improvement to the state of the art:

In Media Lario's former LCT design, the transmitter telescope diameter is much smaller than the receiver telescope diameter, which reduced the antenna gain and thus the achievable link distance. The lower antenna gain has been traded-in for quite a number of benefits: a) relaxed optical wavefront quality requirements of the telescope; b) no need for a point-ahead mechanism; c) no need for a fast steering loop; and d) simplified isolation between transmitted and received light. This new approach is based on the direct detection 1550nm terrestrial fibre technology, so a large number of components are commercially available.

Achievements:

Two complete terminals have been adapted for field test on a link distance of 1.1km for communication at 2.5 Gbit/s. The project has been developed in three phases: Ground Demonstrator Design, Manufacturing Assembly and Acceptance Testing, and Operational Testing. The scope and goals of the project have been achieved, and all optical characteristics have been measured to verify compliance. In particular, Media Lario has demonstrated the possibility to use a single telescope as a transmitter and receiver at the same time, both for 1550nm and 830nm wavelengths. The ground testing established a 2.5Gb/s link with three transmitted beams and three received beams in the same receiver. The operation at 1550nm allows the Media Lario terminal to benefit from low cost fiber optics and lower complexity leading to a small size and low weight terminal. In addition, the electroforming technology used by Media Lario allows for a high optical performance within a large temperature range and a low cost of reliable replication. Overall the field test shows promising results for link stability, power loss, scintillation and transfer. Media Lario now plans to begin far field (5km to 20km) tests and airborne testing and envisages the next step as development of a lightweight Inter-Satellite Link terminal using Nickel electroplated mirrors and telescope structures, to be introduced in the telecommunications market at a very affordable price.

Electroplated Nickel Reinforcement of the Vulcain 2 Engine Nozzle Extension

Keywords: Vulcain 2, Electroplating, Reinforcement, Nozzle extension

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Name of Program: LET-SME
Year: 2003

Overview/Scope of the activity: The reinforcement of the welded Inconel Vulcain nozzle extension is an activity of the VULCAIN II recovery programme of Ariane V. The concept presented by Media Lario is based on a uniform external reinforcement of the nozzle in its critical part by means of an electroplated shroud of Nickel grown directly on the external Inconel wall of the nozzle. The shroud will be thicker at the hottest area of the nozzle, with a controlled thickness reduction along its axes. The objective is to verify the feasibility nickel electroplating as a solution, by means of technological tests and material characterisation of samples and by plating two models - a reduced 1/20 scale model, and a full size sector of a Vulcain 2 Nozzle Extension.

Application Fields: Media Lario's concept has been reviewed and accepted by the Snecma team as back-up for the "welded ribs" solution in the recovery plan of Snecma for the Vulcain 2 engine.

Improvement to the state of the art: Media Lario proposed to apply its innovative electroplating technology in this activity. The electroplating solution has several advantages over conventional solutions, including lower costs, lower mass, less time spent in the reinforcing process and an ability to tailor the actual reinforcement material characteristics.

Achievements: A micrographic analysis of all samples has been performed. Following these tests, a technology demonstration of the plating process was performed whereby the upper part of the Vulcain Advanced Nozzle Extension was plated to a maximum thickness. Tests on the models and the demonstrator have proved that the electroforming tools are able to deposit the specified thickness and taper of Nickel layer. Material Characterisation tests were performed at 77K, 298K, 500K and 700K, and demonstrate that electroplating process parameters can be tuned such that the measured properties of the material are compliant with the baseline requirements and have attained better mechanical performances than requested. Beyond this, Media Lario has proposed an Optimised Reinforcing Concept, in which the deposited layer of Nickel is shaped in terms of longitudinal ribs. This solution assures a lower mass, and shorter plating times. The total electroforming time is reduced from months to just 10 days for the ANE test, and buckling strength analysis predicts an 81 fold improvement in strength at the most critical part.

Adaptation of XMM-ALMA Technology to Demonstrate Refurbishment Capability for the Radio Telescopes of Plateau de Bure

Keywords: Telescopes, Panel Technologies, Plateau de Bure Interferometer, Nickel Panels

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Name of Program: ToT

Year: 2003

Overview/Scope of the activity: A spin-off of XMM technology has been investigated for application for highly accurate antenna panels for the ALMA radio telescope antennas (<25mm rms surface accuracy). Media Lario is nearing a successful completion of 120 panels for the European prototype of the ALMA sub-mm radio telescope. IRAM in Grenoble has 6 sub-mm wave radio telescopes on Plateau de Bure and is in need to investigate and most likely to decide to refurbish the reflector panels of the radio telescopes, being the panel technology of high interest for this purpose. The subject of this project is to realise the structural design of the panels in order to meet the IRAM requirements, for field testing under extreme environmental conditions at Plateau de Bure, and to procure two of the six masters (mandrels) needed for the refurbishment of the panels for the telescopes.

Application Fields: The Plateau de Bure Interferometer is an array of 6 antennas with diameters of 15 m, used for radio-astronomical research. The success of the transfer of a technology developed for an ESA mission to an important commercial market has opened the doors to other possible application of the Nickel electroformed panels to existing radio-telescopes or to new ground based antennas that will operate under very stringent environmental conditions (e.g. the radio-telescope antennas to be installed in the Arctic).

Improvement to the state of the art: IRAM had decided to make heavy use in the initial design of the telescopes of carbon fibre. About 10 years ago, IRAM noticed that the carbon fibre panels, which are covered with a thin plastic film, started to develop defects. As neither the manufacturer nor IRAM could identify a clear cause for this, and also no long-term solution to this problem, IRAM started to look for alternative panel technologies.

Achievements: After extensive trade-off analysis, Media Lario has designed and tested a sandwich panel based on the electroformed Nickel replication suitable for installation on the IRAM PdBI antennas. The shape accuracy of the panel is within tolerance, and with sufficient margin to cope with environmental induced changes. A backing skin heating system has been incorporated and compared with a reflecting skin system which has been shown to be advantageous. Laboratory testing has been successfully completed and operational tests are proposed on a group of panels on a Plateau de Bure antenna. Two prototype panels have been made available to IRAM for this testing.

Development of a Methodology for the Design of Dielectric Filters in Rectangular Waveguide for Space Applications

Keywords: Dielectric filters, Software, Electric Field Integral Equation Method

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Name of Program: INNOVATION

Year: 2002

Overview/Scope of the activity: The objective of this activity is to develop a new methodology for design of Dielectric resonator filters for use in communications satellite transponders. The techniques will use a formulation based on the electric field integral equation, and are intended to give the designer an accurate and efficient tool to for analysis and design of all class of dielectric filters.

Application Fields: Dielectric filters are presently the standard approach for multiplexer design used in communication satellite transponders.

Improvement to the state of the art: Current methods for the design of Dielectric filters need to simulate 8 to 12 coupled resonators, using commercial programs based on Finite Element or Finite Difference formulations. These methods are not practical for speed and memory allocation reasons. This activity develops software that allows the analysis of a complete dielectric loaded filter, including the turning screws, to be performed in about one second for each frequency point. This allows the final optimisation of an entire filter to be performed in a practical and affordable timeframe, representing an improvement to computation speeds of one order of magnitude with respect to current commercial tools.

Achievements: The electric field integral equation has been applied in a very efficient way for the analysis of dielectric loaded rectangular resonators and filters. The high efficiency of the integral approach for the analyses of inhomogeneous structures has been confirmed, considering both dielectric and metallic losses. The full wave analysis of an entire filter including the input coupling and the interactivity coupling has been performed for the first time by using the integral equation method. The computation speed has been shown to be over one order of magnitude higher than existing commercial tools.

Optimum Design of a KA-Band Six Port H-Plane Directional Coupler for Space Applications

Keywords: Coupler, KA-Band, Antenna, Frequency Bands

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Name of Program: ARCoP
Year: 2000

Overview/Scope of the activity: The purpose of this project is to design, manufacture and test a breadboard model of a coupler, which should be used as dividing/recombining network for space solid-state power amplifiers.

Application Fields: This coupler is usable in a variety of applications, especially in those systems (such as multi-beam and re-configurable antennas) which require more compactness, more envelope limitation and more mass reduction of the beam forming networks.

Improvement to the state of the art: The directional couplers are fundamental components for the realisation of power splitting and combining networks. Even though the H-plane multiport directional couplers are more attractive for millimetre wave applications than the E-plane ones, they are rarely found in the literature and they have never been designed nor optimised with the methodology proposed in this work.

Achievements: An optimum layout of a six port H-plane directional coupler has been designed. Different solutions have been investigated and compared using the software available at the University of Perugia. The most promising structure has been selected and optimised maximising the in-band flatness. For this configuration an elegant breadboard has been manufactured and electrically tested. The results of the test campaign performed on the coupler demonstrate the practical feasibility of the component. The comparison between theoretical and experimental results is very good.

Development of a Biophysical Diagnosis Device for the Determination of Vitality and Blood Pressure Status in Man

Keywords: Diagnosis, Biophysics, Vitality, Fitness, Health

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Company Point of Mr. W. Dupont (e-mail: office@mst-aerospace.de; phone ext. 920; fax ext. 443)

Name of Program: ToT

Year: 2000

Overview/Scope of the activity: The objective of this project is the development of a diagnosis device for the determination of vitality (fitness), blood pressure status and heart rate by means of a non-invasive photo-radiometric method to be developed up to a prototype level. It is based on know-how gained in a previous space project; the main further development will consist in the improvement of the reliability against light influences and the development of a user-friendly software to track the evolution of users' hemodynamic parameters.

Application Fields: Fitness diagnosis by determining biophysical parameters. This diagnosis device is suitable to monitor the physical fitness improvement during training programmes in areas of physical education, recreation, leisure and sport.

Improvement to the state of the art: For competitive athletes comprehensive methods exist to measure their health status and fitness; however, for all those people undertaking physical activities during their leisure time there are no possibilities to check their fitness, i.e. to get information about their cardiovascular health status. This device aims at filling this gap.

Achievements: Prototype, hard- and software of the fitness analysis device have been completed. By placing a finger tip on the sensor area it determines the fitness status (absolute value in a range between 15-85), blood pressure and pulse rate (absolute value between 30 and 199, accuracy ± 2). The local skin temperature and personal data are taken into account additionally. Fitness and blood pressure trends of the last days and evolution of main parameters are displayed as bar charts. It allows also the recording of training units of fitness measures undertaken by users.

Solar Antennas based on Si & GaAs Solar Cells

Keywords: Solar Cells, Microwave Rectifier Antennas, Miniaturisation, Monolithic

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Company Point of Mr. Kuckertz (email: info@ohb-teledata.de)

Name of Program: INNOVATION

Year: 2000

**Overview/Scope
of the activity:**

A sensible way for ESA to reduce costs is via mass production and distributed systems and in that perspective micro/nano-technology is an area with particular potential. In satellite design, some constraints faced by the designer are electrical power and mass budgets. Furthermore, the size of both antennas and solar panels are constrained according to the available space. As solar cell technology has been advancing rapidly, with improvements in efficiency, radiation tolerance, cost and weight, it becomes possible to integrate the microwave radiator/antenna and solar cell into (monolithic) building block units. These units may then be replicated as desired to create a structure whose transmitting aperture is also used as the light-collection area. From this point of view it is desirable to integrate (phased) arrays and solid state (solar) devices for communication and radar applications.

Application Fields:

Possible spin-offs could be the Solar Power Satellites (SPS), Microwave Rectifying Antennas (rectennas) and micro-satellites.

**Improvement to the
state of the art:**

As these technologies evolve, their use results in a potential reduction in weight by a factor of ten to a hundred over conventional concepts.

Achievements:

Results obtained are very good. The effect of solar cells on antenna performance and vice-versa is negligible. Presently, the team is working on flight demonstration.

Focal Plane Filter Mosaic (FPFM)

Keywords: Focal Plane Filter Mosaic, FPFM, Manufacturing, Interference, Spectral Analysis, Optics

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Company Point of Mr. E. Schmidt (e-mail: e.Schmidt@oib-jena.de; phone ext. 90; fax ext. 91)

Name of Program: LET-SME
Year: 2001

Overview/Scope of the activity: The aim of this activity is to develop a reliable manufacturing technology for Focal Plane Filter Mosaics (FPFM). These are filters with different spectral transmissions in different areas of the filter surface. Each of them is an interference filter, made of many (up to 50) layers, and any number of filters can be implemented on the FPFM substrate; also, the size of the FPFM and the size and shape of its individual filters can be freely chosen. This is possible thanks to a masking technique developed by OIB and Supracon, which uses a technology applied by the semiconductor industry. Based on this, it should be possible to manufacture high-quality, low-cost multi-layer interference filters for spacecraft, extremely hard and space qualifiable.

Application Fields: The realization of the research objectives will enable (particularly smaller) space missions to perform better multispectral analyses of planets and their satellites with one fixed optical imaging system by placing a multifunctional filter in close vicinity of the CCD camera sensor.

Improvement to the state of the art: The possibility to manufacture FPFM by oxidising the interference filter layers at adequately low temperatures such to maintain the integrity of the photoresist mask, by means of an intermediate step in the manufacturing process. Hydroxides are generated in the first step, at low temperatures. The hydroxides are stable enough to tolerate that the coating chamber is opened and the photoresist mask removed. The hydroxide layers are then transformed into dioxides in a temper process.

Achievements: A technology for the manufacture of high performance patterned spectral filters for space application has been developed and successfully tested. This technology has applications for the ESA project AMIE (as part of SMART-1 satellite), which allows the multi spectral survey of the lunar surface from space using one single optical imaging system. This offers weight saving advantages to the mission and far exceeds the previous limits of the state of the art for the required edge definition accuracies.

Development of a vibration detector based on piezofoils

Keywords: Vibration, Piezofoil, Sensor, Vibration Modes

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Name of Program: ToT

Year: 1999

Overview/Scope of the activity:

The objective of this activity is to develop a piezofoil sensor for industrial production. It has been developed in two phases:
Phase 1 - The sensor must be conditioned, so that standard signals will be provided as requested by industry. The mechanical structure of the sensor has to be designed in a way that the sensor withstands harsh industrial environments. Phase 2 - The implementation of a mass production capability (100000 sensors a year). Further functionality tests for different applications (e.g. fan monitoring in cleanrooms, monitoring of bridges, railways) will be performed in co-operation with client companies. In parallel, a European distributor network will be implemented and new jobs for production tasks will be created.

Application Fields:

Different tasks in various industrial areas. First of all, vibration monitoring functions in machinery (e.g. the application of the sensor for monitoring pumps in chemical and petro-chemical industry). Furthermore, the sensor in connection with a processing unit is suitable for monitoring of machines like paper converting machines, train of rolls, extruder and calender as well as turbines in power plants. Another important application field is the release of airbags in cars.

Improvement to the state of the art:

The main advantage of the sensor is its high dynamic behaviour within a broad frequency spectrum. Low-frequency vibrations can be detected just as high-frequency vibrations. So it is possible to detect all vibration modes which can occur in machines with one type of sensor. A further advantage is the low price if it is manufactured in series, which can open up application fields not accessible by traditional sensors. Furthermore, the sensor is suitable as release sensor for overload and crash monitoring of robots.

Achievements:

Phase 1 - After design and layout of the sensor model and signal conditioning unit handmade models were built up and tested to validate the functionality. These tests were performed by OPS by means of a small water pump, a gear pump and a vibration test box. As the expected performance met the requirements, the production data were generated and the production of sensor and signal conditioning unit started.
Phase 2 - A facility for the production of approximately 50.000 sensors units/year has been set up by OPS. A quality control system for monitoring manufacturing parameters has been implemented, and the production process optimized. A first batch of sensors have been manufactured and successfully tested, and a number of monitoring systems have also been delivered to potential customers for testing purposes.

Development of Wavelet Techniques for Pyrotechnic Shock Analysis

Keywords: Signal, Shocks, Wavelets, Signal Treatment, Pyrotechnic, Transfer Function

Contractor: **RMS - Réalisations Méditerranéennes de Signal**

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Company Point of Mr. L. Vivet (e-mail: rmsmanta@pacwan.fr; phone n. 04 42 33 86 53)

Name of Program: ARCoP

Year: 1999

Overview/Scope of the activity: The purpose of this project is to develop a signal treatment that is necessary to define pyro shock signal very accurately, addressing key points of the analysis and identification of shocks in spacecraft. The establishment of a new type of transfer function based on wavelet approach is needed for the shock qualification of spacecraft.

Application Fields: Shock problems in spacecraft (e.g. urgency of the Ariane 5 shock problems for ESA spacecrafts).

Improvement to the state of the art: The nature of the work is quite innovative, addressing key points in the field of shock analysis. Experts in ESA have tried to initiate such type of activity in the past, without success.

Achievements: Good achievement of the average methodology. Thanks to this study, RMS has from now on some theoretical tools to further study in this field.

Crack Identification System (CRIS)

Keywords: Crack, Radar, Non-Destructive, Rock, Mining, Excavation

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Company Point of Mr. H. Lentz (e-mail: h.lentz@rst-ag.com)

Name of Program: ToT

Year: 1999

Overview/Scope of the activity: The objective of the contract is the adaptation of ground penetrating radar system originally developed for planetary rover application to the assessment of rockmass integrity behind support linings in underground mining. This involves the detection of small aperture discontinuities (cracks) near the excavation surfaces.

Application Fields: In underground mining, support measures often call for surface linings to maintain the integrity of the rock in the walls and the roof as well as to contain any loose materials that may develop. As these measures are generally installed well in advance of mining, they experience maximal loading long after placement. Consequently, there exists a need for a non-destructive technology to permit the assessment of the ground conditions behind these linings.

Improvement to the state of the art: Need for a crack identification sensor that can be handled easily by technicians with no radar knowledge.

Achievements: The test campaign has showed that the radar is capable of mapping cracks as tight as 0.5 mm in a semi-realistic environment and that crack detection algorithms based on planar features proved to produce reliable results on either semi-realistic lab data and known cracks. The new Technology of Stepped Frequency is best suited for Very High Resolution GPR.

Support Development of a New Ground Penetration Radar (GPR) Sensor for Seeking Anti-Personnel Mines

Keywords: Mines, Demining, Radar, GPR, Sensors

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Company Point of Mr. H. Lentz (e-mail: h.lentz@rst-ag.com)

Name of Program: ToT

Year: 1998

Overview/Scope of the activity: HOPE is a project launched by the European Community on the development of a multisensor mine seeker which will improve safety and efficiency in humanitarian demining. HOPE combines a metal detector, a microwave radiometer and a GPR. The GPR sensor will provide very high spatial resolution -in the order of a few centimetres only- and it shall allow to distinguish between false alarms and real mines by identification of spatial characteristics of the feature detected. The ESA developments on GPR during the last years (GINGER & PIRA) have made the GPR technology ripe for this terrestrial challenge. Some problems are still to be solved, being the most important the resolution/penetration factor.

Application Fields: Development of a hand-held multisensor mine seeker, which will allow to distinguish between false alarms and real mines. Other application fields of this technology are: quality control on building basement, health check of bridges, search for ground water, localisation of objects, bodies, etc.

Improvement to the state of the art: GPR has some significant advantages over many other kinds of mine detectors. It detects even plastic mines with no metal at all in it. Novel GPR data processing methods allow to provide a 3D image of the subsurface area and consequently buried objects should be identifiable by its shape. High performance signal processors make it possible to show these images in real-time, even on hand-carried systems.

Achievements: Prototype was successfully tested in the field. For the next phase funding is expected from the EC.

Development, Test and Verification of Analytic S/W for Antenna Coupling

Keywords: Antenna, Design Tool, Electromagnetic Modelling

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Company Point of Ms. C. Laforest (e-mail: claforest@satimo.fr, phone: +33 1 69 29 81 60)

Name of Program: INNOVATION
Year: 2001

Overview/Scope of the activity: The object of the activity is the development of an innovative software tool enabling the simulated testing of an antenna in its final operational environment. An antenna radiation diagram is measured, by the proprietary antenna measurement system of Satimo or any equivalent one, and its measured data are fed to a software simulator that directly produces the radiation diagram that the antenna would have in its operational environment.

Application Fields: Antenna design and verification, for space and other applications.

Improvement to the state of the art: This hybrid tool is unique in its kind. Innovative concepts are applied both in the modelling of the scattering from the environment and in the link between measurement and simulation parts. The first relies on a new way to perform ray-tracing to predict the distribution of electromagnetic fields using the Uniform Theory of Diffraction, which is totally automatic and solves many of the limitations of classical schemes. The second exploits the fact that this new ray-tracing methodology is able to use field distributions specified on a closed surface as inputs so that near-field measurements can be directly used for the scattering calculations.

Achievements: The first tool prototype was demonstrated in May 2003, the actual product is expected to ship by the end of 2003. Continuation activities are on-going to extend the tool capabilities. The possibility to extend the concept with the use of other electromagnetic modelling techniques, like Physical Optics and Method of Moment is under evaluation.

3D Multi-layer Antenna Design

Keywords: Antenna, Multi-Layer, Gain, Bandwidth, Composites

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Company Point of Mr. L. Foged (email: lfoged@satimo.com; phone ext. 234; fax ext. 884)

Name of Program: LET-SME
Year: 2001

Overview/Scope of the activity: The purpose of this proposal is to devise planar antenna elements with higher gain and bandwidth capabilities while maintaining the attractive features of the multi-layer composite technology. During the trade-off study and preliminary design phase, several antenna configurations will be investigated and the achievable and trade-off performances determined. The selected configurations will be optimised and evaluated based on full wave numerical modelling. A few of them will be selected for further optimisation and evaluation in terms of manufacturing and materials requirements. Among these, a few promising solutions will be selected and further optimised for elegant breadboarding and final measurements.

Application Fields: Planar antennas typically manufactured using multi-layer composite technology are widely used in all kinds of applications (mobile satellite communications, DBS reception, GPS systems, etc.). They are especially attractive for their flexibility, manufacturing simplicity and low cost. For space applications it is often the case that the reduced gain-bandwidth capability of this technology poses serious restrictions to its use.

Improvement to the state of the art: The goal is to devise antenna structures that can be easily build using multi-layer technology but have sufficient extension along the third dimension (across layers) to obtain wider bandwidth and higher element gain. The expected electrical performances are an operational bandwidth of 30-50% (return loss < 20dB), a gain of 10-12 dB, good polarisation purity (linear and/or circular, XPD < 18dB). This represents a significant advance with respect to the current state of the art.

Achievements: Three breadboards have been tested showing good results and one has been subject to additional testing the 3D patch (Tower) element was selected for elegant bread-boarding for its very high directivity characteristics. This antenna consists of a feeding section and a surface wave-guide with a termination section. The model has been optimised, tested and compared with a reference antenna. The Tower element has demonstrated dual circular or dual linear polarisations, unachievable by the reference antenna, and furthermore the Tower element is judged to be of low manufacturing complexity, relative to existing alternatives. The performance characteristics for directivity, Bandwidth, Losses, polarisation etc.. make the developed Tower element attractive for many applications formerly supported by helics or other antenna elements such as the Horn antenna. SARIMO intends to promote the Tower element technology for applications in space and non-space fields.

Tele-echography using High-Tech Space Technology

Keywords: Tele-Echography, Medicine, Health, Remote Sites, Tele-Medicine

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Company Point of Mr. O. Merigeaux (e-mail: o.merigeaux@sinters.fr; phone ext. 17; fax ext. 49)

Name of Program: ToT

Year: 2000

Overview/Scope of the activity: The objective of this activity is to assemble an industrial prototype of a portable tele-operated 2-D ultrasound probe-holder, combined with a workstation providing communication tools between an expert and a remote site.

Application Fields: Echography in remote sites using a tele-operated 2-D probe with tools to support decision making of the expert. Target remote sites would preferably include regional medical centres such as maternity and ob-gyn units, cardiology departments as well as difficult access sites (catastrophe areas, mountains) and under-developed countries.

Improvement to the state of the art: Ultrasound examinations, in particular echography, are currently used to support space research in human physiology and space medicine as well. Their main drawback is that the quality of the examination highly depends on the skills of the operator, being this limitation especially critical for examinations in space but also for daily healthcare, because many care centres could benefit from ultrasound examinations, but don't have the required medical experts on the spot when needed. Therefore, tele-echography is a technique to be developed in the near future.

Achievements: An industrial robotized system for ultra sound examination at a distance has been developed. At the end of this stage of the project, the results are very promising. The success is measured with the following criteria: light and reliable structure for the slave system; simple and cost effective solution for the global system; integration with standard components available on the market; and easy to install and use. The project has had a very enthusiastic response in Toulouse and its regional institutions.

Manufacture of a mock up and complementary mathematical models in order to confirm the feasibility of a new type of mandrels for space replicated mirrors

Keywords: Mandrel, Variable Mandrel, Mirror, Optics, XEUS, Telescope, Manufacturing

Contractor: **Société Européenne de Systèmes Optiques (SESO)**

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Company Point of Mr. J.-F. Carré (e-mail: jfc@wanadoo.fr; phone ext. 8521; fax ext. 8585)

Name of Program: LET-SME

Year: 2000

Overview/Scope of the activity: The scope of the proposal is to demonstrate the feasibility of a new process of variable mandrel manufacturing.

Application Fields: Mandrels are used in space X-ray missions such as XEUS telescope project. The mandrels foreseen for XEUS are Zerodur fixed mandrels, needing 500 (one different type for each XEUS shell). This number could be significantly reduced by using variable mandrels.

Improvement to the state of the art: Using its knowledge in FEA modelisation for flexible optics with benders, in polishing, in integration, SESO has defined a new type of mandrel compatible with manufacturing processes. This new process will allow to manufacture variable mandrels and then reduce the budget of mandrels by a factor 2 to 3 (in XEUS project, the order of magnitude of this budget is initially around 150 millions euro).

Achievements: The activity has presented a distortion map of some variable mandrels, a final design and mock up results, with a proposed development plan for XEUS mandrel fabrication. This work has explored a new technical area which is of decisive importance in the future.

Engineering tool for Qualification of Optical Coatings

Keywords:

air-vacuum transition, test equipment, optical coating qualification

Contractor:

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Company Point of

Gilbert Dahan

Name of Program:

LET-SME

Year:

2004

**Overview/Scope
of the activity:**

The scope of the activity is to study and develop a standard methodology to test the behaviour of the optical coating during the transition air to vacuum.

Application Fields:

Space application

**Improvement to the
state of the art:**

The added value of the expected performances of the new equipment is the ability to realise a vacuum of 10⁻⁶ Torr, to measure "true" reflectance, to measure the out gazing elements, and to heat the sample.

Achievements:

Contract has been completely terminated and the results have been presented to the ICSO 2006 conference Noordwijk .In order to keep the system operating an agreement with Institut Fresnel is going to be signed in which the bench will be installed and keep operational in Institut Fresnel who will be able to make its own tests by itself for research activities, free of charge. For measurements involving commercial or industrial results, SESO will make direct quotation and will use the bench in Institut Fresnel premises.

High Temperature Cartridge Development

Keywords: Cartridges, Material Science, High Temperature

Contractor: SOTEREM

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Company Point of Mr. B. Bonduelle (email: bruno.bonduelle@soterem.fr)

Name of Program: INNOVATION

Year: 1998

Overview/Scope of the activity: The aim of the activity was the development of a cartridge based on the technology used in Advanced Gradient Heating Facility (AGHF) and upgraded for experiments in the future Material Science Lab (MSL) furnaces up to a temperature of 1600o C. The activity was intended to yield a cartridge based on conventional proven technology, suitable for the temperature range of the MSL furnaces as a low cost and reliable solution.

Application Fields: Material Science and laboratory experiments in furnaces up to a temperature of 1600o C.

Improvement to the state of the art: The use of Tantalum as cartridge material for the temperature range up to 1800o C has been theoretically assessed and demonstrated up to a temperature of 1600 oC. Subtechnologies developed within this activity include the brazing process (tantalum/stainless steel) to the cold end of the cartridge and the feed through and cementing of the thermocouples into the cartridge. This technology will allow experimentation in material science in the MSL at temperatures as high as 1600oC.

Achievements: A high temperature cartridge based on Tantalum technology has been developed and tested at 1600o C in the MSL furnaces.

Commercial WCET Tool

Keywords: WCET, Worst Case, Software, Static Analysis, Real Time, Testing

Contractor: **Space Systems Finland Ltd.**

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Company Point of Mr. Sami Laitinen (sami.laitinen@ssf.fi) tel: +358961328623, fax: +358961328699

Name of Program: ToT

Year: 1999

Overview/Scope of the activity: The SSF WCET tool -currently being developed under an ESTEC contract- uses static analysis in order to verify that a real-time computer system meets its deadlines, by measuring the execution time of test cases and computing execution time bounds by analysis of the code. The proposed activities are market analysis (including discovery of applications and customers), further technical development of the tool, development of the company organisation to sell and support the product, and pre-release validation by pilot projects.

Application Fields: Real-time computer systems, where failure to meet a deadline for some action or response could lead to serious consequences ranging from user irritation (poor quality of service) to significant financial losses or even injury or death. Target applications of this software tool are Aviation, Automotive and Telecom industries, as they are large enough and they were anticipated to contain at least some hard real-time requirements. Also Nuclear Power Production or Medical Instrumentation are potential targets.

Improvement to the state of the art: Many companies have already a variety of in-house developed systems for testing. The SSF WCET tool needs to show increased reliability, cost effectiveness, speed of testing and productivity in order to be able to replace existing methods.

Achievements: The extension of the tool was performed only for the Intel 8051 processor during this project due to the limited project budget. This project has produced for SSF useful information and experience about demands of potential customers and awareness of a potential market segment for the tool as well as about a market survey process. The next development phase -outside of this project- has started with the potential partner that has been found as a result of SSF's own contacts and commercialisation activities performed during the CW CET project.

Data Processing Close to Sensor

Keywords: Remote Sensing, Segmentation, Classification, Digital Signal Processors, DSP, Data Processing, Sensors, Neural Networks, On-Board Image Segmentation, Image Processing

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Name of Program: LET-SME

Year: 2001

Overview/Scope of the activity: The purpose of this project is to demonstrate benefits of Digital Signal Processors (DSPs) and to evaluate their performance and applicability in space applications. As the amount of data increases, there is a need for use of smart sensors, containing data processing facilities. For most of the sensors this is not yet possible. This project investigates the problem where a small processing core and Software is used as a sensor data pre-processor. The two specific objectives are summarised as:

- 1) To develop a software library to be used in digital image processing in an embedded environment.
- 2) To evaluate the feasibility of on-board image segmentation using current space qualified hardware.

Application Fields: Possible applications areas for this technology:-

- 1) On-board Classification of data.
- 2) Cases with limited downlink bandwidth.
- 3) Areas of sea only, or areas too cloudy can be autonomously discarded as not of interest.
- 4) Application of different compression rates: "interesting" images could be compressed with lossless algorithms and others with higher compression rates (and greater associated losses).

Improvement to the state of the art: The main goal of this study is to gain experience and exploit the use of multipurpose Digital Signal Processors (DSPs) in space applications. They offer significant speed gain in calculation-intensive applications. This extends the satellite on-board applications into the area of resource demanding data processing. This includes signal processing, math algorithms, image processing or image understanding of some level.

Achievements: The study shows that on the 21020 DSP at 33MHz it is feasible to perform on-board segmentation of images having sixteen spectral channels or more with a ground resolution of 150m. Areas for optimisation have been identified, giving the possibility of further performance improvements up to a factor of two or more (allowing up to 32 spectral channels or more).

A library of digital image processing functions has been produced covering sensor modelling, Image manipulation, Image arithmetics, Grey-scale point operations, Local operators, Edge detection, Geometrical operators, Binary operators, logical operators, Area based matching and Utility.

Overall, this activity has shown that autonomous on-board image analysis using existing hardware is realistic, and further demonstrates that on-board data selection is the best solution to manage large amounts of data.

HOPE / Project for Antipersonnel Demining

Keywords: Mines, Demining, Radar, GPR, Sensors

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Name of Program: ToT
Year: 1998

Overview/Scope of the activity: This project is intended to achieve a detection probability for anti-personnel mines as high as possible to guarantee the security for the deminers and the local population and to achieve a false alarm rate as low as possible to minimise the clearance time. These performances can only be reached by using a multi-sensor system using a complementary sensor set: a metal detector, a ground penetrating radar (GPR) and a microwave radiometer for the indication of flushed mines. The proposed handheld multi-sensor system will be verified continuously during the whole project by field tests by the consortium and the expertise of the end-users, and finally evaluated in the clearing areas in Angola, Bosnia, etc.

Application Fields: The objective is to produce a handheld mine detection equipment that should be built with the lowest possible cost, be able to detect plastic mines, be reliable by achieving a clearance result close to 100%, be operational in different environmental conditions and terrain and take into account the existing, reliable and efficient demining procedure and a large number of deminers familiar and educated with these procedures.

Improvement to the state of the art: For the first time in a hand-held system, a microwave radiometer (MWR) will be used, primarily for the indication of flushed mines. The measured outputs will be processed with advanced methods for signal processing, feature extraction, pattern recognition and data fusion. Additionally, a decrease of the false alarm rate will be achieved by supporting the feature extraction, pattern recognition and data fusion by simulating and modelling the signatures of the most common types of mines and also modelling most likely types of false targets.

Achievements: Software tool successfully incorporated in the prototype, which was successfully tested in the field. For the next phase funding is expected from the EC.

Non Intrusive Telemetry Acquisition

Keywords: Telemetry Acquisition, Non Intrusive, Monitoring Systems, Miniaturisation

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Company Point of Dr Jean-Luc Josset (e-mail: jean-luc.josset@space-x.ch)

Name of Program: LET-SME
Year: 2001

Overview/Scope of the activity:

In space, operational satellites are prototypes. 'Learning from flying' is limited since the priority is given to the payload telemetry and the engineering telemetry is limited to a simple health monitoring. The goal of this project is to provide a first approach and demonstrator of a spacecraft monitoring system that wouldn't need many spacecraft resources in terms of mass, power, volume and especially telemetry bandwidth. In-flight monitoring would greatly enhance the engineering return on systems that are usually unique, but it may not impact negatively on the main aim of the mission, its scientific objectives and therefore the allocated bandwidth for science telemetry.

Application Fields:

There are numerous applications of a wireless monitoring system. Some of them are: coverage of key events, like module separation, deployment of solar panels, etc.; regular monitoring of solar panels or electrical propulsion systems; the possibility to use this monitoring system as an emergency sensor for the AOCS; also, the impact of wireless communications is important for the on-going research for On-Board Data Handling Systems; finally, for public relations it is important to have images or films such as descent images, or stereovision systems for rovers and landers, that allow the public to understand the importance and impact of space exploration.

Improvement to the state of the art:

The innovation sought is the miniaturisation of the whole system. The microcamera shall not weight more than 100 g, the thermal radiation acquisition package shall not exceed 50 g (including transmitter), the data acquisition unit shall not exceed 200 g, including storage and processing, and finally all elements should be powered either from secondary 5 volts or on internal battery.

Achievements:

The project has shown the feasibility of a non-intrusive telemetry acquisition system for engineering purposes and has allowed the identification of possible uses and future needs for such a system. The needs identified are: Thermal Characterisation, further miniaturisation, adaptation of Data Acquisition unit interfaces with Spacecraft bus, power supply improvements, and an investigation into optical transmission versus RF transmission systems.

Industrial Application of Spectral Imaging for In-line Sorting

Keywords: Colour, Spectrometer, Spectrum, Light, Imaging, Spectral Imaging, Colour Control

Contractor: **SPECIM, Spectral Imaging Ltd.**

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Company Point of Mr. T. Hyvärinen (email: timo.hyvarinen@specim.fi; phone ext. 495; fax ext. 496)

Name of Program: ToT
Year: 1999

Overview/Scope of the activity: The objective of this contract is to design, develop and test a prototype spectrometer to solve in-line spectral classification and sorting problems in the ceramic sector and later on other industrial applications. This system is based on the application of a patented high performance hyperspectral imaging spectrometer for aerospace applications -named AISA-, which uses a high efficiency PGP spectrograph able to register the light spectrum from ultraviolet to infrared with throughput independent of light polarisation.

Application Fields: The colour control of tiles is presently performed by human operators. This solution is expensive and not reliable. The AISA technology has been developed for earth observation and explicitly addressed to precision farming and environment control, but thanks to its compactness and robustness, it could find promising applications outside the space sector in the development of spectral imaging systems for laboratory and industrial use.

Improvement to the state of the art: Currently no on-line system for on-line colour inspection of ceramic tiles is available on the market, and methods currently used concern off-line spectrophotometer techniques used in laboratory. Spectral imaging due to its good spectral resolution will provide improved colour measuring capability over currently used RGB (Red-Green-Blue) camera based systems.

Achievements: A system prototype for on line measurement of colour spectrum was designed and implemented. The work focused on developing a reflectance measuring head and optical fibre cables connecting up to 8 measuring heads to one light source and one spectrograph/camera unit. Also, on line colour measuring software was developed. Testing the prototype system proved that it was capable of measuring colour difference below human eye resolution, and maintained stability over time and large variations in ambient temperature. The system results and prototype have been utilised to stimulate the development of several other color measuring and sorting applications by SPECIM's collaborators and customers in the fields of textile and wood and laminate production, printing process control, and forensic investigations.

Application of a Space Born Innovative Gearbox System to the Automotive Sector
SPACEGEAR

Keywords: Gearbox, Drive-train, Motion Transmission

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Company Point of Mr. M. Perrone (e-mail: stam_genova@yahoo.com)

Name of Program: ToT

Year: 1999

Overview/Scope of the activity: The activity aims at applying an innovative gear drive-train system to the transmission of motion of electrically driven parts in a car, by designing, manufacturing and testing a prototype high-ratio gearbox. The gear concept is based on an earlier development of a deployment mechanism for a space application (Deployable Retrievable Boom of the Tethered Satellite).

Application Fields: Various applications in a number of electrically driven parts such as rear-view mirrors, windows, antennas, seat adjustments, windscreen wipers, roof, hoods, etc.

Improvement to the state of the art: The system has the following major advantages: simple configuration (only four gears) which will reduce the manufacturing costs by 20-40%, small size and weight compared to alternative solutions and high efficiency and reliability.

Achievements: The suitability of the SpaceGear concept for a compact motor-reducer unit has been demonstrated. A prototype has been built and tested, with the specific target application in the automotive sector (seat reclining mechanism). It has been shown that the reducer is adaptable for a wide range of gear transmission ratios at promising torque-to-mass and power-to-size ratios, and with satisfactory efficiency levels.

Analysis of C, C++ and SystemC based Systems using Software Static Analysis Tools

Keywords: SystemC, C, C++, Coding, ASIC, VHDL, Development

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Name of Program: LET-SME

Year: 2000

Overview/Scope of the activity: ASIC developments mainly use VHDL as the modelling language. SystemC is a new language complementing C++ with relevant objects for ASIC developments. The goal of the activity was to assess the language, based on a static analysis tool existing for C, and to be complemented for SystemC by adding the necessary rules.

Application Fields: SystemC is being heavily promoted by many of the major EDA vendors involved in the development of tools for hardware design. Consequently, the same need for SystemC guidelines will emerge as many vendors start to employ SystemC in the development of their designs. The consequence of this is that ESA must work to develop its own set of guidelines for high quality and maintainable models developed using SystemC as well as VHDL.

Improvement to the state of the art: An example of this is the GEANT4 program, where a small set of coding guidelines were developed, which enabled a very distributed group of software developers to work on a major C++ software development and yet produce code that would conform to a basic set of guidelines.

Achievements: After final presentation at ESTEC, the opinion of the ASIC section was that VHDL is more appropriate than SystemC for ASIC developments and that the languages are driven by the tool vendors and it is difficult for ESTEC to have a policy here. It seems that SystemC was a technology opportunity for their development, but the context is relatively difficult for the moment. They made a good job with a good reporting, but the situation didn't help.

Earth's Application Possibilities of the Process of Water Treatment

Keywords: Water Treatment, Filtration, Membrane

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Name of Program: ToT

Year: 1998

Overview/Scope of the activity: Assessment study on Earth application possibilities of the water treatment process developed by ESTEC in the "Water Recovery" programme. This study makes use of membrane filtration systems in water and wastewater treatment processes.

Application Fields: The "Water Recovery System" has a broad range of applications - those initially identified for study are:
Potable water production, from turbid waters, coloured waters, waters with organic micro-pollutants and brackish waters;
Electronics: provides rinse waters low in colloidal, organic and ionic impurities;
Food and beverage: for process, make-up and high purity rinse waters;
Boilers: provides water low in sodium and organics for product formulation or washing;
Cosmetics: provides water for product formulation or rinsing applications;
Planting: spot-free rinse and solution make-up water;
Drinking water: reduces minerals and improves taste;
In this study in particular target : mineral water companies.

Improvement to the state of the art: Problems in recovering water from the various sources by a regenerative systems are typically linked to the presence of low molecular weight organic compounds, which are difficult to remove either by phase-change or by membrane technologies, and to the presence of specific microflora susceptible to contaminate the water recovery system. Conclusions from successive studies have demonstrated the excellent potential of membrane-based technologies for purifying moderately contaminated waste waters such as hygiene water and condensation water. In this context it should be noted that 95% of waste water is recovered.

Achievements: With the development and improvement of membrane filtration systems, higher quality of drinking water and higher efficiency in wastewater treatment were achieved. Nowadays membrane technologies are widely used in fields such as: water and wastewater treatment plants, food and beverages industry, cosmetic industry, etc.

Transfer of Neural Network Technology

Keywords: Neural Networks, Fuzzy Logic, Control, Engine, Automotive

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Name of Program: ToT

Year: 1999

Overview/Scope of the activity: The initial purpose of this proposal is to present an internal transfer of a specific technology developed in a space programme (Neural Networks, used for the equalization of satellite signals) towards automotive electronics (engine control units). The objective is to control a thermal piston engine through a neural network in order to get cutting edge tuning of the engine whatever the environmental conditions (temperature, pressure, humidity) and whatever the engine mechanical and physical conditions (fuel, manufacturing tolerances, worn).

Application Fields: The ultimate application is for mass production cars and it is investigated by such companies as Siemens or Magnetti Marelli. Applications in Formula 3 race boats are also possible.

Improvement to the state of the art: Cutting edge tuning of an engine whatever the environmental conditions and whatever the engine mechanical and physical conditions.

Achievements: Neural Networks were abandoned in favour of Fuzzy Logic Technology, as it was better suited to process deterministic control. In aerospace, Fuzzy Logic enables very complex real time problems to be tackled using a simple approach. The project was developed in two phases: simulation and physical implementation of the controller and control of a simulated engine. This implementation has been successfully demonstrated.

Grasp Preprocessor

Keywords: Processor, Reflector Antenna, Flexible architecture, TICRA, Software Tools

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Name of Program: INNOVATION

Year: 1998

Overview/Scope of the activity: To develop and implement a new preprocessor for the GRASP reflector antenna analysis program based on a flexible architecture so as to make it suitable for the use also with other TICRA software tools.

Application Fields: Reflector antenna analysis and design for satellite applications and beyond.

Improvement to the state of the art: The GPAD tool resulting from this development adopts several new technologies derived from advanced IT solutions making it possible to run many different tools from the same user friendly front-end.

Achievements: The availability of a single modern front-end tool usable for existing and future TICRA antenna design tools.

Integrated Software Tool for the Design, Analysis and Optimisation of Planar Waveguide

Keywords: Antennas, Array Antennas, Waveguide, Software, Design, Slotted Arrays

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Name of Program: LET-SME

Year: 2000

Overview/Scope of the activity: The objective is to implement a dedicated software tool for the design of slotted arrays by integrating modelling software developed by TICRA in the past and optimisation tools (also based on available proprietary software) with an updated version of the User Interface Manager developed under a previous SME activity. The user interface will enable advanced and flexible access to the steps of the complete design and analysis process in a way that is natural to the antenna engineer, including graphical rendering of the antenna system components, and will enable dynamic updating of visualized radiation patterns.

Application Fields: Array antennas, which are receiving increasing attention for space applications, not only in Europe but also on a worldwide basis.

Improvement to the state of the art: The proposed tool is expected to make the design and synthesis procedure much easier to carry through. The software will include specially tailored tools for the problem specification and for managing and supervising the single steps. Further, the separate design steps will be linked together in a natural way via the harmonisation of all data flowing through the procedure from step to step. The new optimisation modules will provide a complete up-to-date suite of programs for this type of antenna. These modules shall include a pattern optimiser based on a Genetic Algorithm and an optimiser offering minmax patterns optimisation.

Achievements: This project has been completed according to plan as specified in the proposal and the contract. Major problems have been avoided and all essential proposed goals have been reached. Furthermore, some extra features and options for the system that were not described in the proposal have been added including the OpenGL graphical rendering feature. The final result of the project is a very useful system, which even exceeds previous expectations.

Low cost KA-band return channel transmitter for interactive digital TV satellite broadcasting applications

Keywords: Transmitter, Return Channel, KA-band, Digital TV, TV, Interactive TV

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Name of Program: ARCoP

Year: 2000

Overview/Scope of the activity: The purpose of this project is to design and develop a hardware prototype of a "low cost KA-band return channel transmitter for interactive digital TV satellite broadcasting applications". This project is product-oriented, as the final target is a hardware unit with potentially broad market application. It focuses in the feasibility demonstration of an innovative concept, which is at an early stage of development.

Application Fields: Transmitter for interactive TV using DBS return channel.

Improvement to the state of the art: The implementation of a transmitter capability in the user receiver terminal for DBS satellite applications will allow having a low data rate return (control) channel. This is seen as a key issue in the future of digital TV interactive service provision (e.g. ASTRA is expanding its multimedia services with a new KA-band two-way satellite link).

Achievements: A laboratory prototype of the transmitter has been successfully developed that demonstrates the feasibility of the concept. A truly low cost product will require further development however.

Laser Plasma Spectrometer for Planetary Exploration

Keywords: Spectrometer, Planetary Exploration, Laser, Plasma, Spectroscopy, LPS, LIPS, Raman Spectrometry

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Name of Program: LET-SME

Year: 2000

Overview/Scope of the activity: The objective of the activity is to carry out a feasibility study including the definition of a flight model conceptual design for a new and innovative instrument for elemental in-situ analysis called Laser Plasma Spectrometer (LPS).

Application Fields: Used on planetary exploration missions, this instrument has the potential to carry out repeatedly elemental analysis of surface material in a time frame of some seconds for each measurement. By means of a pulsed laser source, surface material is brought to a plasma state which allows to apply emission spectroscopy for the detection of its elemental composition. Target missions are explorations on Mars or Mercury.

Improvement to the state of the art: Current analysis methods such as Alpha Proton X-Ray spectroscopy have proven to produce valuable results. They impose however rather hard constraints with respect to on-surface operations (measurement time) and applicability (sample size and shape, sample contamination and impacts of the surrounding atmosphere). An instrument that can perform in-situ analysis of the chemical element composition instantaneously and without special constraints for sample preparation would be an important improvement for gaining experimental data of unknown planetary surfaces.

Achievements: The concept of a Laser Plasma Spectrometer for planetary exploration was developed in a good quality. Further investigation will be needed but the first step is made. The results of this activity allowed to define an even more flexible instrument by combining Laser Plasma Spectrometry (LIPS) with Raman Spectrometry, in order to achieve a compact laser-optical facility for geochemical and mineralogical in-situ analysis. The results led to the consideration of the combined instrument as a baseline instrument for the EXOMARS mission.

Image Application Processing Server - IAPS

Keywords: Image, Database, Imagen Processing Server

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Company Point of Mr. G. Serrecchia for orig. project (e-mail: giuseppe@webbridges.it) and
Mr. M. Pichini for CCN (e-mail: massimo@webbridges.it)

Name of Program: ToT

Year: 1999

Overview/Scope of the activity: The objective of this project is to develop a general image application processing server for distribution of image products in areas other than space. The idea of this product is based on the ImageDB server developed by Web Bridges for the ESA/ESRIN in the context of the Earth Watching program, a system for on-line access to specific collections of quick-looks and images derived from Earth Observation data. Its flexibility will permit its use also in areas not conceived as the original target, by improving the following parameters: image compression, sub-image extraction and delivery and association of text to images.

Application Fields: The use of the ImageDB system has already been extended to the creation of specific collections in support to training, promotion, public relations, but still in the remote sensing domain. However, during the development stage of the ImageDB, Web Bridges has internally evaluated the possibility to extend and generalise framework and features of the system, in order to adapt it to requirements of markets other than remote sensing.

Improvement to the state of the art: A tool for automated indexing and retrieval of images stored on disk, with basic image reprocessing, key-wording and annotation capabilities is not currently available on the market.

Achievements: IPAS 1.0 was finished on time (with limited delay due mainly to external causes), and with all technical objectives met. The tool has been designed, developed and tested and the possible application and market areas have been identified. It provides basic image re-processing, key-wording and annotation capabilities. The strength of IAPS 1.0 can be summarised in terms of simplicity of use, generality, small size and speed and efficiency.

Device for Home Resistive Exercise using Space Technologies

Keywords: Exercise, Training, Muscle, Physiology

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Company Point of Mr. O. Sejnäs (e-mail: yoyotech@telia.com; phone: +46 8-258724)

Name of Program: ToT

Year: 1999

Overview/Scope of the activity: YoYo is a non-gravity dependent mechanical device, which provides resistance during coupled concentric and eccentric muscle actions, through the inertia of a spinning fly-wheel. The aim of this project is to take advantage of this innovation -originally intended for space use- and design a user-friendly exercise apparatus for applications on Earth. An initial phase will validate the feasibility and efficacy of this instrument. It will subsequently be redesigned to comply with customer need and industrial production.

Application Fields: Portable training apparatus for both home use and medical rehabilitation. This instrument allows for exercises of the lower and upper extremities as well as chest, back and the trunk.

Improvement to the state of the art: The exercise-system has important features that makes it very feasible for resistance exercise from a physiological standpoint. High force, isometric, concentric-eccentric muscle actions can be performed at a low caloric expenditure. The system favours so-called functional, multi-joint, stretch-shortening exercises. Multiple muscle groups can be exercised in one machine. It is user-friendly. Despite the power of this system exercise using this loading principle appears safe.

Achievements: The following tasks have been undertaken: upgrade of business organization; travels have been made for negotiations with subcontractors and potential licensees; two resistive exercise ergometers have been purchased; market tests and evaluations have been made; an upgraded market research has been performed and homegym design has been improved.

Business Expansion of the Fly Wheel YOYO Technology

Keywords: Flywheel, Exercise, Fitness, Technology Transfer

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Name of Program: ToT
Year: 2002

Overview/Scope of the activity: YoYo has developed an exercise system based on flywheel technology and designed for use in space. This novel and patented system is intended for use on the International Space Station (ISS). Because of its unique features it is also attractive to implement this technology in the design of home- and fitness exercise systems and devices for use in sports, sports medicine and other clinical settings. This activity seeks to redesign the existing exercise system for use in space, into configurations for terrestrial application and subsequently, manufacture and market these products.

Application Fields: Sports, home training, health and fitness, athletics, and sports medicine and rehabilitation.

Improvement to the state of the art: Flywheel resistance exercise is a unique system patented for several applications. This flywheel loading principle has been employed into a compact, multi-exercise configuration that will save space and use of weights whilst allow for exercise of a broad group of muscles.

Achievements: The following tasks have been completed:

1. Three multi-gym exercise units was delivered at ESTEC and on-site introduction and orientation sessions provided by YoYo Technology in the month of July, 2003.
2. Brochure "The choice of astronauts in their home away from Earth..." (1 copy mailed)
3. Interactive (DVD) manual (1 copy mailed)
4. User's manual; print and DVD (1 copy mailed).
5. Market survey.