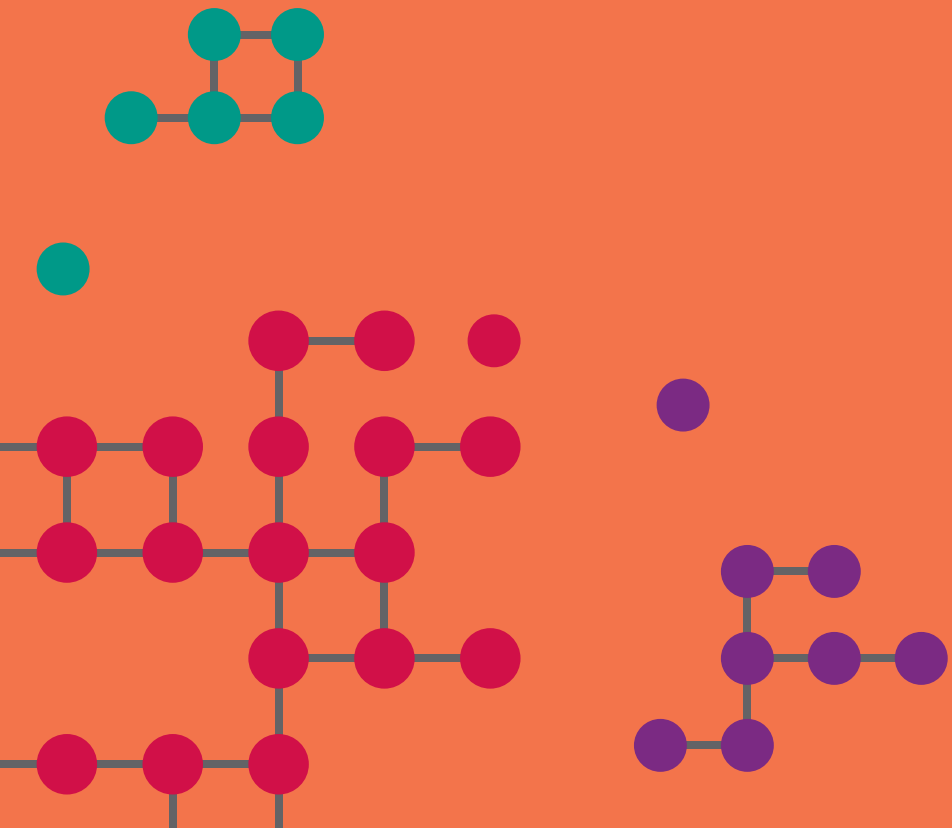
Technology Strategy Board
Driving Innovation

Collaboration nation

Innovation in Space



Working in collaboration with:

Introduction

This directory of projects we helped to fund provides an overview of the opportunities highly innovative companies can offer across the UK through their developing technologies. It can also be used to help link those companies to the wider funding community in order to develop their ideas into new products, processes and services.

Feasibility studies for innovation in space

We invested approximately £2m in 77 innovative projects across the UK space industry as part of a plan to ensure that small and micro businesses in this country are well equipped to respond to society's greatest current and future challenges. The South East England Development Agency (SEEDA) contributed £0.64m to projects in the region and this was matched by those companies participating.

The work builds on the growth opportunities highlighted in our Space Innovation and Growth Strategy (IGS) and will exploit the facilities and open innovation culture of the International Space Innovation Centre (ISIC). A good balance of projects across the key areas of the IGS and the National Space Technology Strategy was achieved.

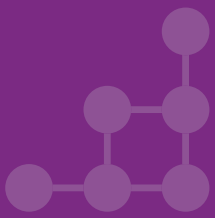
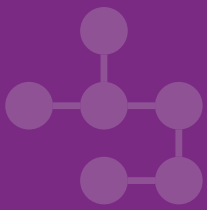
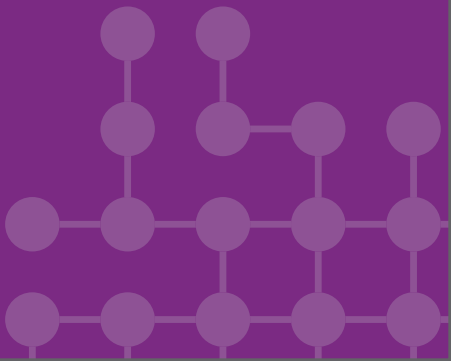
Each three-month project received up to £25,000 to explore the development of innovative commercial technologies for space or to look at new services which exploit data gained from space-based systems.

Some projects were conducted by single companies whilst others were carried out by collaborative consortia. A good mix of small and medium-sized enterprises (SMEs) and larger companies participated in the competition and there was a wide geographical spread. Many of the entrants were new to the space sector.

The entries in this directory are divided into six different categories – telecommunications, propulsion, applications, spacecraft components, instruments and CubeSats.

This directory provides a snapshot of the winning projects so that potential future collaborators, investors and companies interested in open innovation can get to know the companies involved.

Telecommunications

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Algotronix Ltd

Algotronix develops and supplies intellectual property (IP) cores which implement cryptographic algorithms on field programmable gate array (FPGA) chips.

Feasibility of creating a MACsec IP core for enhanced security of satellite communications

What is the project?

Our project assesses the feasibility of using the IEEE 802.1AE media access control security (MACsec) standard to secure a communications link to a satellite using our MACsec intellectual property (IP) core for field programmable gate arrays (FPGAs).

What are the potential benefits?

Ethernet is by far the most successful networking technology and has a massive ecosystem of companies supporting it. An ethernet link to a satellite secured by MACsec would allow the space industry to leverage this commercial off-the-shelf infrastructure and potentially reduce development costs. Industry standards such as MACsec, which have received intense scrutiny during the standardisation process, are also preferable from a security viewpoint.

What is the challenge your project addressed?

Our challenge was to develop a MACsec IP core suitable for space use. The complexity of implementing MACsec provides a challenge in itself as does the relatively low performance and density of space-rated radiation-hardened FPGA chips. The non-technical challenge is to convince potential customers of the benefits of Ethernet secured by MACsec compared with existing space industry communications standards.

What are the next steps?

We will continue to develop our MACsec IP core, which is attracting interest for 10G and 40G optical ethernet networks and point-to-point microwave, while looking out for opportunities in the aerospace market. This would include networking to aircraft as well as satellites. Obtaining European Space Agency approval of MACsec is an important step in opening the satellite market.

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Astrium UK

Astrium UK is a recognised world leader in the design/ manufacture of satellite and space technology.

Direct up-conversion for space communications

What is the project?

All satellites – telecommunication, navigation, broadcast, observation and science – use a traditional, analogue radio frequency (RF) up-convert stage to communicate with Earth. For the first time, a space-grade digital-to-analogue converter (DAC) with the ability to directly up-convert a digital baseband input to an analogue RF output has become available. This innovative technology could greatly simplify or eliminate the traditional, analogue RF up-convert stage using one single low-power device.

What is the challenge your project addressed?

We were given first access to a new DAC which offers direct up-converting features. Our aim was to assess the suitability of direct DAC up-conversion techniques for use on future space applications. The key challenges were to understand and compare the level of performance that could be delivered by a direct up-converting transmitter. Can direct up-conversion be realised using current hardware and be deployed into near-term projects?

What are the potential benefits?

Our study has shown that the use of direct DAC up-conversion can deliver a digital transceiver with a 40% reduction in volume, a 20% reduction in mass, a 40% reduction in power consumption and a 12% reduction in cost. Our ability to deliver a payload exploiting the above benefits gives UK industry a major technical and commercial advantage when competing for global tenders.

What are the next steps?

Astrium UK leads the world in the de-risking and application of direct DAC up-conversion. We are trying to identify suitable opportunities within the space, electronics and telecommunications industries to commercially exploit our lead in direct conversion. We would like to offer prospective customers the benefits of reduced volume, mass, power consumption and non-recurrent and recurring costs.

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Avanti Communications Ltd

Avanti Communications supplies satellite broadband and data connectivity services to business, institutional and residential customers.

ZEUS – integration of satellite multicast/broadcast for next generation mobile networks

What is the project?

We set out to scale the requirements and cost of the backhaul (the links between the central or core network of the provider and the sub-network such as cell towers) for the next generation Long Term Evolution (LTE) network. Our findings show that while urban environments are well connected through fibre and microwave links, rural areas still lack cost-effective infrastructure to cope with even basic demand. Our proposed ZEUS concept, using hybrid terrestrial copper backhaul and satellite broadcast network, is an alternative cost-effective means to address the capacity requirements in these locations.

What is the challenge your project addressed?

Video download is expected to represent 66% of all mobile data traffic by 2015. Mobile backhaul costs account for 52% of a mobile operator's network cost. Future 4G/LTE base stations supporting high-quality video content will pose a costly challenge for today's terrestrial backhaul networks. Satellite backhaul with wide-beam coverage is the most efficient delivery mechanism for broadcast/multicast content but, unfortunately, is not supported today.

What are the potential benefits?

We anticipate backhaul cost savings of up to 50% with satellite broadcast/multicast offload technique using hybrid copper and satellite backhaul when compared with microwave links and leased fibre. Our intention is to target 10% of LTE macrocell base stations when deployment starts in 2013. This figure could be significantly higher if femtocells and software-defined radio base stations are included.

What are the next steps?

We have split the next phase into three parts. During the pre-development phase, we will raise awareness with potential partnerships. In the 15-month development and trial phase, Zeus will be developed and trialled, potentially with funding support from the Technology Strategy Board. In the post-development phase, the results from trials will be exploited with relevant partners in the industries, predominantly the mobile operators and content providers that are key to the successful commercial offering of the service.

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Avanti Communications Ltd

Avanti Communications supplies satellite broadband and data connectivity services to business, institutional and residential customers.

KASM – Ka-band Satcom on the Move

What is the project?

We have recently launched the Ka-band, bi-directional, communications satellite HYLAS-1 and expect to launch HYLAS-2 in 2012. KASM, Ka-band Satcom on the Move, is a feasibility study looking at the possibility of introducing communications-on-the-move (COTM) and communications-on-the-pause (COTP) services over a Ka-band satellite from a technological and commercial point of view.

What are the potential benefits?

Ka-band satellite communication services, including COTM and COTP services, have been used in the military sector for some years now. Recent advances, with Avanti as a forerunner in Europe, have made such services available to residential, business, and institutional customers as well. With KASM as a starting point, we hope to introduce Ka-band satellite-based COTM and COTP services to business and institutional customers.

What is the challenge your project addressed?

The aim of KASM was to prove the feasibility of introducing COTM and COTP services in the regions covered by HYLAS-1 and HYLAS-2. On the technical side, the aim was to identify technological issues surrounding, in particular, Ka-band COTM services and to identify equipment vendors and their capability to solve them. The commercial feasibility for such services was also reviewed, focusing on introducing services in regions covered by our satellites.

What are the next steps?

With the information we gathered in KASM, we are ready to approach equipment vendors for discussions of technical and commercial trialling of Ka-band COTM and COTP services under selected scenarios. Before trials, we may need to further develop our proprietary Network Management System to support equipment integration and to handle functions for issues not solved by our selected equipment vendors.

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Avanti Communications Ltd

Avanti Communications supplies satellite broadband and data connectivity services to business, institutional and residential customers.

Smartphone application for satellite broadband installations (Satbis)

What is the project?

Our smartphone application for satellite broadband installations (Satbis) project aims to exploit the capabilities of current smartphones and tablet devices to develop a proof-of-concept application for automating the most labour-intensive and time-consuming tasks involved in satellite installation and commissioning. The aim is to ensure fast, accurate terminal set-up without requiring much participation or support from the satellite network operations centre or service provider.

What is the challenge your project addressed?

Satellite broadband installation and reporting is a challenging and laborious process that requires use of a spectrum analyser, digital multimeter, power meter, camera, GPS receiver, compass, inclinometer, cabling and other tools. Together, this equipment weighs upwards of 12kg. Satbis seeks to reduce the amount of equipment needed by exploiting the capabilities of current smartphones and tablet devices, thus facilitating the process of satellite broadband installation for field engineers.

What are the potential benefits?

We expect our network of resellers and virtual network operators (VNO) to perform around one million installations for Hylas-1 and 2, and estimate the cost savings for each installation using the Satbis application to be at least £20 per installation based on increased productivity. Potentially, the application generates substantial strategic value, allowing the recruitment of less skilled installation engineers, quicker service roll-out and reduced training.

What are the next steps?

We will develop the application further for trials by Avanti's field engineers and network of resellers and VNOs and explore the possibility of further reducing the number of devices needed for installation. We are also looking to develop a backend diagnostic knowledge base that exploits the data contained within the Avanti Operations Support System (OSS) to provide users with intelligent fault detection, failure mode diagnosis, and, ultimately, prognosis.

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e2E Services Ltd

e2E Services provides consultancy, design, development and integration of satellite communications systems.

Load testing of on-demand radio networks

What is the project?

Our study investigates the potential for a lightweight simulator to load test on-demand satellite communications networks prior to deployment. It looks at the ability to model loading scenarios that may be encountered, such as high loading in response to a crisis in a geographical location, using lightweight, simplified and targeted simulation models that can be used to test the network before the operational deployment.

What is the challenge your project addressed?

Congestion and high traffic loads in on-demand networks occur by their very nature at important times of day or in critical locations. The adverse effects of loading are therefore very apparent to users and mitigation strategies need to be developed and tested. Conventional network testing approaches involving real equipment are prohibitively expensive and related performance issues tend to require intensive management to minimise the impact to subscribers.

What are the potential benefits?

Our feasibility study has allowed e2E Services to develop an architecture for a real-time simulation infrastructure that can be used for simulating test loads for on-demand satellite communication networks. The simplified simulation of the user terminal behaviour that is provided by the load simulator offers a cheap, flexible and effective way of providing a representative load for the network in these critical and difficult-to-create test scenarios.

What are the next steps?

The next stage of development for the load simulator will be to implement an initial proof of concept, based on the case study design that was developed in the feasibility study. We need to do further work on simulating additional protocol behaviour and components of the initial target system, and some work on applying the load simulator to other on-demand radio networks.

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e2v technologies (UK) Ltd

e2v is an established, large UK-based company developing and manufacturing high-technology components and systems.

Development of high-frequency, space-qualified travelling wave tubes (TWTs), a market assessment

What is the project?

Our project delivers information on the developing market for high-frequency TWTs for space application. The report will inform our on-going debate on whether or not it makes business sense for e2v to enter the space TWT market.

What are the potential benefits?

This proposition is some years from implementation. If we were successfully to compete in the space TWT market, sales of several millions of pounds a year could easily result. Additionally, the improved manufacturing techniques required for space-qualified TWTs would benefit our established business in ground-based devices.

What is the challenge your project addressed?

We were looking at straightforward questions on the potential market for high-frequency space-qualified TWTs. Who are the established players and who will be the potential customers? What TWTs will they require, when will they want them and how many will they want? How much will they pay for them and what is the likelihood of e2v getting part of that business?

What are the next steps?

Although sales of space-qualified TWTs of several millions of pounds per year are possible, the costs of setting up to develop and manufacture such devices have to be carefully evaluated. A thorough analysis of the cost of setting up for space TWT manufacture against the increased sales and profit to the company has to be completed and this is to be addressed by our management.

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Fell Systems Ltd

Fell Systems provides technical and commercial consulting services to satellite manufacturers and operators.

Maximising user choice to mimic pull video on demand in non-linear satellite broadcast

What is the project?

Our project demonstrates packing algorithms which facilitate an efficient non-linear content delivery network. This can be used by satellite broadband operators to multicast popular content, reducing demand for point-to-point download capacity and increasing the number of customers served. Depending on the relative costs of bandwidth and user storage, this will be used to provide consumers with the widest possible choice of on-demand video with imperceptible delay.

What is the challenge your project addressed?

TV viewers are showing an appetite for video on demand. Current linear broadcast networks are inefficient at providing viewers with the degree of choice that is available on the internet and the required internet broadband network capacity is not yet universally available at the speeds required for TV broadcast quality. The challenge is to show that satellite broadcast can mimic the Internet and provide a similar user experience to video on demand.

What are the potential benefits?

Three broadband satellite operators have entered the European market with services available over the UK and several others are operational elsewhere. Many more are planned and these provide an opportunity for sales of the non-linear programme packing software. There is also an opportunity as a service partner depending on the positioning of the satellite operator. This applies to most developing countries and, with a change in regulation, to all UK broadcasters.

What are the next steps?

The main aim of our study was to plan a field demonstration/pilot. An operator and a content provider/broadcaster have agreed to join a partnership for a pre-commercial pilot. A proposal to the Technology Strategy Board's Collaboration Across Digital Industries 2 (CADI2) initiative has been submitted and we anticipate that a pilot will be tested in 2012 applied to local and community TV on demand. Investment partners are needed for commercial roll out.

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Hollycroft Associates

Hollycroft Associates was formed in 2001 and is a management and technical consultancy company in space, satellite communications and related fields.

Ka-band tracking very small aperture terminal (VSAT) antenna for mobile satellite communications

What is the project?

Our study looks at the feasibility of developing and subsequently marketing a UK-sourced and produced Ka-band tracking antenna system for use in the mobile environment.

What are the potential benefits?

There is a significant market for such a terminal. In the maritime sector, the Euroconsult Maritime Telecom Solutions by Satellite report states that the addressable market is some 75,000 vessels – all of which are targets for a Ka-band upgrade following the availability of Inmarsat Global Xpress in 2014. The aeronautical sector is approximately half the size of this opportunity, the rail sector is much smaller at about 1,000 trains.

What is the challenge your project addressed?

Launch of the UK Avanti HYLAS satellite and the European Eutelsat Ka-Sat satellite marked the beginning of a new era in lower-cost higher-bandwidth satellite communications. These satellites respond to the clear and present needs of the transport sector (including trains, boats and planes), but as yet there are no compact Ka-band tracking terminals available in the market. There is an opportunity to develop a UK-based capability in terminal technology.

What are the next steps?

Inevitably, following this feasibility study, we now face a significant cost in bringing the product to market. We plan to address this through a proposal to the European Space Agency Advanced Research in Telecommunications Systems (ARTES) programme, which if successful may fund up to 50% of the cost of development; through direct investment by the companies involved in this feasibility study; and through third-party investment from a sponsor customer.

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MESL Microwave

MESL designs and manufactures microwave and electronic components and subsystems for telecommunications, defence and space.

Low-loss ferrite switching circulators for space applications

What is the project?

The aim is to design and manufacture a Ka-band latching circulator, with lower insertion loss than currently available, by using a novel reduced-height geometry. A combination of magneto-static and high-frequency modelling was used to optimise the magnetic biasing of the ferrite resonator and the microwave performance of the latching circulator to provide initial designs. Prototype parts were then manufactured and tested.

What is the challenge your project addressed?

Our aim was to produce a latching junction circulator giving less than 0.15dB insertion loss over a 5% to 10% bandwidth. The major difficulties in the project were accurate manufacture of the very small Y-shaped resonators required at Ka-band and the difficulty in adequately magnetising a reduced-height ferrite resonator due to the increased magnetic reluctance of the thinner resonator walls.

What are the potential benefits?

Insertion loss is one of the critical parameters for system performance and often several latching junction circulators are present in a typical space application, so the lower insertion loss provided by this innovation would provide an important benefit for system designers. The lower insertion loss would also lead to lower dissipated power, which can alleviate thermal problems.

What are the next steps?

To present an individual switch or subsystem product to the space market, we will have to develop an electronic driver to control the microwave device. We are looking for a partner experienced in the design of space electronics and will work with this partner to adapt existing MESL driver designs to suit the space application.

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SciSys UK Ltd

SciSys was established in 1980 and specialises in software solutions across a broad market including space.

Dynamic evaluation of performance against service-level agreements

What is the project?

Our study considers the use of complex event processing (CEP) as a technology to monitor and evaluate real-time satellite operations' performance against customer service-level agreements. This will allow mission operators to make commercially informed choices in the prioritisation of their service. Our study required dialogue with end-user operators, CEP technologists and the establishment of operational scenarios that work through the issues.

What is the challenge your project addressed?

Satellite communication operators expect to provide services to their customers at an appropriate level of performance. The actual quality of experience of these customers is therefore a key parameter. The problem for operators is that performance against delivered service is evaluated retrospectively, giving little opportunity to dynamically manage resources to ensure best business performance. This leads to loss in customer confidence. Complex event processing offers a potential way to alleviate this.

What are the potential benefits?

The CEP-based monitoring approach defined by us has been welcomed by operators as a means of managing scalability of future satellite operations in terms of both service volumes and complexity of satellite systems. The provision of real-time statistics on quality of service and monitoring of the system against stored profiles of expected behaviour offer prospects for improved business efficiency, avoiding operational cost increases that would otherwise arise.

What are the next steps?

Our CEP solution comprises a concept for its (automated) operational application to satellite communications. This focuses on quality of experience and the detection of unexpected degradation in mission performance. While there is strong interest from the operators consulted, the solution needs to be demonstrated before they will purchase. We will work with satellite operators and CEP technologists to prototype such a tool.

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VIPER RF Ltd

VIPER RF delivers microwave (DC-100GHz) design consultancy and intellectual property generation for wireless communications and defence.

Ultra-compact, high-efficiency, low-cost packaged gallium arsenide (GaAs) 10W high-power solution for Ka-band communications

What is the project?

This project investigates the feasibility of developing a cost-effective, high-performance concept for achieving 5W-10W of output power at Ka-Band in a compact and lightweight package. We explore innovative concepts for efficiently combining multiple GaAs monolithic microwave integrated circuits (MMICs) within cost-effective packaging technologies with the aim of developing modules with state-of-the-art performance. We also evaluate the trade-off between single-chip integration and a system-in-package solution for Ka-Band power amplifiers.

What is the challenge your project addressed?

With increasing use of Ka-Band for satellite communications, recent specifications for packaged power amplifiers require high saturated output powers in the order of 5W-10W with the capability to operate linearly at lower power levels. At lower frequencies, this can be addressed by emerging gallium nitride (GaN) technologies, but significant challenges exist in delivering such powers at Ka-Band with GaAs. This study aims to develop concepts to produce high power efficiently and cost-effectively.

What are the potential benefits?

Successfully implementing low-cost, high-efficiency Ka-Band power amplifiers will assist in lowering costs for integrators delivering systems to meet the demands for satellite broadband internet access. This feasibility study has allowed us to generate innovative intellectual property with the aim of entering into the supply chain of this rapidly growing market.

What are the next steps?

Concepts for an innovative high-power Ka-Band amplifier module based on packaged GaAs technology have been investigated and they could offer a low-cost route to generating higher power than current commercially available solutions. We are seeking partners and input from system integrators to optimise the performance requirements and take the product towards a full demonstrator and beyond.

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VIPER RF Ltd

VIPER RF delivers microwave (DC-100GHz) design consultancy and intellectual property generation for wireless communications and defence.

High-power, high-efficiency gallium nitride (GaN) hybrid and monolithic microwave integrated circuit (MMIC) power amplifiers for space applications

What is the project?

Our study investigates innovative concepts for the development of solid-state GaN power amplifier modules capable of delivering high output powers efficiently and cost effectively. Successfully implementing circuit architectures such as Class-F and Doherty configurations on GaN will improve efficiency by up to 50%, compared with equivalent gallium arsenide (GaAs) offerings. Integration into a GaN MMIC will reduce the module footprint and complexity of the assembly, further reducing costs.

What is the challenge your project addressed?

The emergence of commercially available GaN technology with power densities significantly greater than incumbent technologies allows for the development of a new generation of solid-state power amplifiers with improved powers and efficiency for C-Band satellite communications. The challenge is to deliver solutions on an emerging technology which perform at high frequencies in compact forms and at a cost comparable to current offerings.

What are the potential benefits?

Successfully implementing improved efficiency, higher power C-Band power amplifiers in smaller forms will assist in lowering costs for system integrators. This feasibility study has allowed us to generate innovative intellectual property with the aim of entering into the satellite communications supply chain.

What are the next steps?

We have investigated concepts for an innovative high-power, high-efficiency GaN module which could offer a low-cost route to the generation of higher powers than current commercially available solutions. We are seeking partners and input from system integrators to optimise the performance requirements and to take the product to a full demonstrator and beyond.

Propulsion

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AMPAC ISP UK Westcott Ltd

AMPAC designs, manufactures and tests liquid rocket engines for satellite propulsion systems.

Feasibility study for an optimised 1N monopropellant thruster nozzle for Earth observation, telecoms and navigation missions

What is the project?

The aim of this work is to examine the feasibility of developing an innovative 1N hydrazine thruster with an optimised contoured nozzle. Using computational fluid dynamics (CFD), the advantages of a contoured nozzle will be assessed over the standard conical nozzle. Any improvements in nozzle performance translates directly to an increase in operational life/lower system weight. The inclusion of a contoured nozzle enhances the innovative thruster design, which is focused on long endurance.

What is the challenge your project addressed?

The 1N thruster can use a conical nozzle, however with the application of modern CFD analysis codes, a superior nozzle may be designed which could lead to significantly enhanced performance. This will further increase the attractiveness of the AMPAC thruster, or may give additional room for down-tuning the engine's performance to realise higher endurance, hence improving competitiveness.

What are the potential benefits?

The future market for 1N monopropellant thrusters for the period 2010-2019 is expected to grow by about 22%, in line with the latest Euroconsult World Market Survey. If this innovative design is developed and qualified, our market penetration in Europe can be predicted to increase to 50%. We would expect to gain around €0.75m per annum of orders with obvious benefits to UK Plc.

What are the next steps?

Our CFD work is already part of a larger European Space Agency (ESA) Advanced Research in Telecommunications Systems (ARTES) thruster program, and the work peformed up to project completion has proven highly useful in keeping the engine development focused. The CFD work performed has uncovered previously ignored avenues of performance improvement which AMPAC and Cranfield are keen to pursue further. Further CFD analysis will provide a more optimised solution and superior real-life correlation.

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Bristol Spaceplanes Ltd

Bristol Spaceplanes was founded in 1991 and specialises in spaceplane design.

The Ascender entry-level spaceplane

What is the project?

The Ascender entry-level sub-orbital spaceplane has low cost and risk. It would be profitable in its own right and would pave the way for the first orbital spaceplane, which in turn would greatly reduce the cost of access to space and bring in a new space age. Our project carries out market research, updates the business plan, and builds a radio-controlled flying model.

What are the potential benefits?

Spaceplanes will bring in a new space age. There will be a rapid expansion of space science and exploration and public access will become the largest business in space. There will be wide economic, environmental, and educational benefits. Many new jobs will be created. Our project has identified a suitable initial market with the potential to recover development costs and has significantly strengthened our business case.

What is the challenge your project addressed?

We have found a way to reduce the cost of access to space by at least 100 times with vehicles whose prototypes can be built at low cost and risk using existing technology. As a micro company, we need industrial partners to bring the project to fruition. The study was to help answer the most frequent question asked by potential partners: how big is the market?

What are the next steps?

Our next step is to find industrial partners (14 aerospace companies were consulted during the project) to build a spaceplane technology demonstrator. We have found a way of building such a demonstrator in only three years for as little as £15m. Following this, Ascender proper could be in service within another two years and the orbital spaceplane in a further six.

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EADS Innovation Works

EADS Innovation Works develops innovative solutions in the areas of mobility, security and the environment.

Electrochemical self-sustaining plasma propulsion

What is the project?

Our project is a feasibility study between EADS IW and the University of Surrey into the potential of a proposed plasma power generation system, believed to be capable of generating enough electrical energy through the electrochemical potential of a fuel-oxidiser combination that it is able to self-sustain the plasma. The excess power, beyond the requirements to sustain the discharge, is harnessed to generate thrust.

What is the challenge your project addressed?

Our project aimed to develop a high-fidelity plasma simulation of the proposed concept that could be used to evaluate the feasibility of the system. The simulation is based upon a particle-in-cell (PIC) model, allowing realistic prediction of the electrochemical processes and loss rates due to thermal wall interactions, radiation, electrical excitation and chemical reaction. An energy balance was used to indicate the concept feasibility.

What are the potential benefits?

This technology could have a significant societal impact if proven to be successful. Numerous potential application areas have been identified including space, aerospace, automotive and military sectors. The common link between all potential applications lies in the exploitation of the self-sustaining nature of the plasma reaction. Although preliminary, the results of this study suggest that the self-sustaining plasma power cycle may indeed be feasible.

What are the next steps?

Our next step is to demonstrate this technology experimentally in a laboratory study, building on the experience gained through the 3D PIC simulation. This laboratory demonstration would allow study of the proposed plasma process and evaluation of the technology for spacecraft propulsion. To be successful, this demonstration will require both industrial collaboration and public funding support to balance the high level of risks associated with the concept.

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Flux Engineering Ltd

Flux Engineering is a developer of advanced propulsion systems for scientific, commercial and military spacecraft.

High-temperature resistojet for all-electric spacecraft propulsion

What is the project?

This project aims to increase the fuel efficiency of spacecraft propulsion systems and reduce the cost and dependence on hazardous chemical propellants by developing a high-performance, low-power resistojet thruster. The thruster operates by heating an inert gaseous propellant to extremely high temperatures using novel design, materials and manufacturing processes. This gives rapid acceleration of the propellant to very high velocities, significantly improving fuel economy and enabling novel missions.

What is the challenge your project addressed?

Small spacecraft are generally limited in on-board resources and are generally incapable of carrying high-performance propulsion systems, limiting their mission spectrum. In contrast, high-value commercial and scientific spacecraft, which do carry advanced ion thrusters, are generally required to carry a secondary low-thrust chemical attitude control system, considerably increasing cost due to the use of hazardous propellants. Our resistojet could address both of these issues.

What are the potential benefits?

Our thruster technology will allow small spacecraft to expand their mission spectrum with greater propulsive performance within the current on-board constraints. On large commercial and scientific spacecraft, which carry advanced propulsion systems, our high-temperature resistojet could eliminate the secondary chemical system and provide a highly integrated inert electric propulsion system with significant cost and risk reduction, giving greater mission flexibility.

What are the next steps?

The resistojet is in the developmental phase and, due to the extremely high temperatures involved, various novel manufacturing solutions are currently being tested. Once we have completed a final prototype, a performance characterisation will be made on a thrust balance in vacuum. We will then move towards a product by seeking a partner, customer or licenser to achieve space qualification through a flight opportunity.

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Flux Engineering is a developer of advanced propulsion systems for scientific, commercial and military spacecraft.

Advanced hollow cathode emitters for long-life gridded ion thrusters

What is the project?

Gridded ion thrusters are becoming an ever more enabling technology for military, commercial and scientific spacecraft due to their high propulsive efficiency. Our project aims to develop long-life gridded ion thrusters which are able to fulfil the longevity requirements of these missions. This includes developing a solution for the short lifespan of the internal hollow cathode component of ion thrusters.

What are the potential benefits?

We have defined a revolutionary concept of electron emitter production which would greatly benefit current ion thrusters. This technology has the potential to reduce the production time of eight-to-nine months to a few days. Increasing ion thruster lifetime could significantly bolster telecommunications and broadcasting business in the UK, worth 24% and 68% of the £7.5bn UK annual space turnover respectively.

What is the challenge your project addressed?

The lifetime of any one thruster is highly dependent on the lifetime of the hollow cathode, which is currently limited to approximately three years. In order to meet the demands of future missions, particularly in commercial telecommunications, a key requirement is to increase the lifetime of the hollow cathode electron sources. Gridded ion thrusters must demonstrate operating lifetimes in excess of seven years to be a viable solution for telecommunications and satellite broadcasting platforms.

What are the next steps?

After we have completed a final prototype, a performance characterisation and accelerated life test will be made in vacuum in a full technology demonstration program. Once the new hollow cathodes have demonstrated desirable operational characteristics, we will test them in configuration with an ion thruster. We will then seek space qualification through a flight opportunity.

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Reaction Engines Ltd

Reaction Engines is developing Skylon, a reuseable space vehicle offering low-cost access to space.

Investigation of damage tolerance of thin titanium matrix composites

What is the project?

We are considering the use of titanium metal composite materials for the construction of the main space frame of the Skylon space plane vehicle. However, the thin walls of the tubular struts in this structure may be prone to defects. The main aim of our project is to see if mechanically testing thin material samples with known defects can be used to establish their strength compared with undamaged samples.

What are the potential benefits?

Our work offers a method of assessing defects and damage to this material. If successfully developed, each Skylon vehicle will require about 50,000 struts, with an estimated manufacturing value of about £125m per year for the space frame alone. Although this work is directly relevant to Skylon, it is also applicable to other uses of these materials in the aerospace industry.

What is the challenge your project addressed?

We wanted to determine if testing of small samples with known internal and external defects could provide test data for use in conjunction with non-destructive examination (NDE) techniques to develop acceptance criteria for defects to this material. The impact of these defects has not been addressed before and it may not be practical to prevent their occurrence in practice.

What are the next steps?

We next plan to carry out further testing, including the effects of creep and fatigue, using an improved tensile test specimen design. We will develop a database that could be used in conjunction with NDE techniques to determine acceptance criteria for damage and defects in these novel materials. The relative merits of options for monitoring the structural health of the Skylon vehicle now need to be assessed and conceptual designs developed.

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Reaction Engines Ltd

Reaction Engines Limited was established in 1989 and designs and develops advanced space transport and propulsion systems.

Precooler isolator modelling for hybrid single-stage-to-orbit propulsion systems using advanced computational fluid dynamics

What is the project?

Our study concerns the efficient integration of a high-performance precooler into a unique hybrid engine cycle (known as the Synergetic Air-Breathing and Rocket Engine or SABRE). The overall performance of this engine cycle, on which the integration of its precooler can have a direct impact, is crucial to the realisation of a fully reusable single-stage-to-orbit vehicle (known as Skylon).

What is the challenge your project addressed?

Our feasibility study aims to help to de-risk the SABRE engine development program (and therefore bring substantial cost savings) by addressing the unknowns associated with the integration of the precooling heat exchanger into the engine nacelle. This study completed a thorough computational modelling and experimental program to understand the losses due to turning the flow as it passes from the initially annular ring to the exit of the precooler.

What are the potential benefits?

The development of SABRE and Skylon alone would represent a long-term high-tech employment opportunity through the development and sale of a much-needed transport system to the world market in space access vehicles. As many as 70,000 jobs could be created and sales could be in the tens of billions of pounds. Furthermore, there is a huge potential for spin-off activities within the aeronautical industries.

What are the next steps?

We have taken immediate steps to identify the exact measurements which can be taken in the upcoming experimental campaign at Reaction Engines to validate the computations. Follow-on projects include modifications to the inlet to minimise total pressure losses and optimisation of the precooler design to deliver a more even total pressure profile at the exit. Funding for these follow-on studies is being actively pursued.

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Stress Analysis and Design Engineering Ltd

Stress Analysis and Design Engineering specialises in stress analysis and design of structures, mainly in the aerospace field

A novel composite segment joint of a heavy-lift launch vehicle booster

What is the project?

Our project looks at the development and analytical improvement of the conceptual joint design between composite case segments of a heavy-lift launch vehicle's solid rocket motor (SRM) boosters. The conceptual designs have been developed and adjusted for the specific requirements and dimensions of the Ariane 5 booster. Non-linear finite element analysis of the assembly has been used to improve the sealing efficiency of the joint. The assembly procedure has also been developed and improved.

What is the challenge your project addressed?

The study of the composite-to-metal joint advances the development of the general conceptual design of high-temperature, high-pressure composite barrel joints, and permits the determination of the main performances of the design. Two conceptual designs have been developed. Investigation has shown that one is more suited to high-temperature/high-pressure applications. The other is proposed for use in low-pressure or non-pressurised composite assemblies such as a rocket inter-stage connection.

What are the potential benefits?

The next generation European launcher program can be realised with a powerful, lightweight and relatively cheap SRM booster. Realisation of this program could push the UK space industry into a leading position on development and manufacture of the next generation of launchers.

What are the next steps?

We need to carry out a more detailed investigation of the geometry and a more detailed analysis of the relationship between the geometrical parameters and the joint strength. The next steps are to improve the performance of the joint design; develop and manufacture a scaled prototype; develop, manufacture and test (cold burst pressure) a full-scale SRM composite segment case; and manufacture and test (operational pressure and temperature loading) a full-scale SRM case.

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Surrey Satellite Technology Ltd

SSTL is the world's premier manufacturer of small satellites and associated technology and services.

Use of electric propulsion to lower the cost of Galileo

What is the project?

The high energy requirement for launch of Galileo satellites to 23,000km means the launch has become the major space segment cost. The recurring cost of Galileo satellites is €30m and the cost of launching them into space is over €35m per satellite. The main challenge addressed by our study is whether the cost of 'on orbit' Galileo satellites can be reduced by use of electric propulsion and cheaper launch scenarios.

What is the challenge your project addressed?

Our study analysed the feasibility and potential cost saving that could be made by using electric propulsion. The scenario analysed is the use of cheaper launch vehicles to launch the satellites to low Earth orbit (LEO). The electric propulsion system would then be used to raise the orbit from LEO to medium Earth orbit (MEO). The additional cost of the electric propulsion system on the satellite should be more than compensated for by the lower launch cost.

What are the potential benefits?

As Galileo is an enduring system it will require many further satellites with associated launches to maintain the constellation. A saving of €10m per 'on orbit' satellite could be achieved, which could translate to many hundreds of millions of Euros over the long term.

What are the next steps?

Our study has established the feasibility of some scenarios for the use of electric propulsion and the saving of launch costs. The electric propulsion system is capable of meeting the mission's propulsion needs and can be accommodated without impacting the Galileo function. Further study is now needed on mechanical and thermal aspects. Such studies could be performed nationally or via the European Space Agency or the European Commission.

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TISICS Ltd

TISICS develops and manufactures lightweight high-strength corrosion-resistant silicon-carbide-fibre-reinforced titanium.

Review of titanium composites in space applications

What is the project?

We needed a better understanding of the potential requirement for titanium composites in space systems, of the key industry groups and of the route to uptake for the composites. We made good links into the European Space Agency and other key players and learnt that we will need to generate material qualification data to enable designers to use titanium composites in space missions. We also gained two opportunities to design parts, one of which could be used on a 2012 mission.

What is the challenge your project addressed?

Titanium composites have not been used in space in Europe and the only other supplier is American. We have a civil aircraft industry background and did not know whether the technology offered technically and economically viable alternatives to conventional materials. We need to raise awareness of titanium composites and also understand where to target the material for the best value to users.

What are the potential benefits?

Titanium composites could reduce the weight of structural components, freeing up space for payload. A kilogram launched into space will cost between £10k and £20k and, according to an ESA engineer, a kilogram of structural mass saved could save another kilogram in propulsion and positioning system and propellant mass. Pressure vessels came high as a potential part with a value of £150k to £250k each.

What are the next steps?

We will continue to develop a pressure vessel for TechDemoSat and a potential Mars Explorer part. We will also identify funds and partners to generate the essential material qualification data needed for ESA approvals, and identify and develop new applications. We need to raise awareness of the technology, and membership of the International Space Innovation Centre (ISIC) will assist with this, as will regular contact with ESA. We will also focus on development of pressure vessels for future products.

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ARGANS Ltd

ARGANS was established in 2007 and specialises in remote sensing and software engineering in marine, atmospheric and terrestrial environments.

Operational detection of oil spills using optical satellite

What is the project?

Our aim was to assess the potential and limitations of optical satellite data to discriminate an oil spill's spectral signature from the signature of natural substances commonly present in coastal waters. The first step was a literature review to summarise what had previously been published. Then, the spectral (wavelength) bands where the oil signature is predominant were considered in terms of developing operational spill detection and characterisation algorithms.

What is the challenge your project addressed?

Oil spills can destroy marine life and damage animal and human habitats, which may have a significant financial impact on both the local population and country/region more generally. Optical remote sensing is generally not considered due to its perceived limitations – its use is restricted to daytime and depends on clear skies. However, it may represent an underutilised complementary resource to radar imagery.

What are the potential benefits?

Current operational services have been based on radar measurements – synthetic aperture radar (SAR). However, SAR detects changes in surface roughness so unambiguous operational differentiation between oil and other surfactants is difficult. Therefore, spectral signatures may aid this process and offer the potential for improved broad-scale spatial and temporal tracking of slick location and movement. The market sectors are regulatory bodies plus oil companies (exploration and distribution).

What are the next steps?

The next stage would be software prototyping and application to a larger satellite dataset so that the uncertainties/confidence limits can be determined. Assuming this is successful, we would develop an operational service. The service could be operated by us or we could supply the expertise and/or products to a data product/service provider.

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Astrium GEO-Information Services

Astrium Geo has been a leading provider of geographic information, software and services for over 25 years.

Characterisation of the PHenology and Vegetation Earth Observation Service (PHAVEOS) detection thresholds for environmental change detection and monitoring

What is the project?

The PHenology And Vegetation Earth Observation Service (PHAVEOS) combines the unique observing capabilities of the spaceborne MEdium Resolution Imaging Spectrometer (MERIS) instrument with non-conventional processing to provide enhanced mapping of vegetation change. Our study sets out to quantify the reliability and variability of a range of PHAVEOS vegetation products and so determine their sensitivity to the detection of vegetation change.

What is the challenge your project addressed?

The derivation of biophysical parameters from Earth observation data is hampered by day-to-day variations in lighting conditions, atmospheric water vapour, clouds and aerosols. Over time, these variations result in noise which is superimposed over the underlying signal of vegetation and environmental change. Being able to quantify and compare the noise and reliability of different biophysical parameters and indices will guide the targeting and marketing of applications of the service.

What are the potential benefits?

There is clear potential for using high-frequency time series of vegetation maps to support a variety of applications, from ecosystem monitoring to analysing pressures on biodiversity and forest health. PHAVEOS offers highly cost-effective daily environmental monitoring (£60k a year for a national scale service). As well as quantifying reliability, our project has generated a seven-year baseline time series in advance of the launch of the operational Sentinel 2 and 3 platforms.

What are the next steps?

Based on the lessons learnt from the study, our next steps are to test an alternative form of atmospheric correction, expand the portfolio of biophysical products offered and then move on to an operational service demonstration. One such application is as a biophysical map supplier to the European Space Agency-funded disease vector mapping (VECMAP) project.

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Chronos Technology Ltd

Chronos is the leading UK company in telecom timing and global navigation satellite system interference detection monitoring.

DETECT: Portable detection and location technology for global navigation satellite systems

What is the project?

DETECT tests the feasibility of current and near-term technologies as the basis for a commercially viable portable global navigation satellite system (GNSS) interference detection and location solution. It sets out the relative merits of different technology options, including the cost and time to to turn them into suitable commercial products. It also analyses the commercial and technical risks associated with the longer-term development of suitable technologies and it establishes the need for further funding and quantifies the time to market.

What is the challenge your project addressed?

UK law enforcement and security services need portable, cost-effective systems for detecting and locating interferers swiftly but these do not exist outside of bespoke solutions for the military market. DETECT assessed different options for portable GNSS interference detectors from two perspectives – likely early adopter markets and most likely technology. In the process, existing technological solutions were evaluated either from a desktop perspective or through testing.

What are the potential benefits?

The benefit to society of low-cost GNSS interference detection capability is an increase in the detection of the use of illegal global positioning system jammers. The use of these 'illegal to operate' devices is now at epidemic proportions and our law enforcement and other government agencies have little or no ability to detect such devices at point of use. Chronos could become a world leader in interference detection monitoring (IDM) technology.

What are the next steps?

Further development of the ideal professional/industrial solution is unlikely to proceed privately without significant further development grant funding. The commercial risk is far too great for a small or medium-sized company to invest in developing it for a domestic UK market that is currently significantly challenged regarding new investment. The barriers to export are far too great to risk such an investment for a wider European or global market.

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eCityRisk

eCityRisk is a specialist provider of exposure, damage and loss information to the insurance industry.

Post-disaster ground-up loss estimation for the insurance industry

What is the project?

Our study provides a proof-of-concept demonstration of the viability of space-based products to provide information on financial losses to property caused by natural catastrophes. The aim is to see if the information that can be obtained from remote sensing using space-based satellites, aerial and ground-based sensors (maybe including drones) can be translated using sophisticated mapping, recognition and matching tools to provide an estimation of damage and financial loss.

What is the challenge your project addressed?

UK and international financial regulators wish to provide rapid and accurate reporting to ensure policies are settled and sufficient capital exists with the (re)insurer for ongoing trading. Currently, considerable uncertainty surrounds post-catastrophe loss estimation. No systematic methodologies exist and, given the performance of existing approaches after disasters such as Hurricane Katrina or the Japan earthquake, the market is open to a rapid space-based approach offering transparent and accurate results.

What are the potential benefits?

The potential market impact is significant, but it varies with the number of catastrophes occurring each year, the number of companies writing business within the impact zone, and perceived cost savings in terms of risk and uncertainty reduction. Formal price-discovery is an important next step, and a conservative estimate of the market size is £2m-10m, assuming four-to-eight events a year and initial uptake of the offering by 1%-5% of companies writing property and casualty business.

What are the next steps?

We need to establish awareness and credibility within the market place and organise resources, suppliers and customers in preparation to respond on a contingent basis. There are four key issues in delivering such a service – improved estimates of potential damage, pre-arranged access to dataset and imagery sources, preparation of rapid channels to market to respond to urgent demand and identifying suitable human resources for an efficient damage analysis. Additional financial support (for example from the European Space Agency, Technology Strategy Board, and the Engineering and Physical Sciences Research Council) is needed for these developments.

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G2way Ltd

G2Way was established in 2010 to develop navigation and communication systems.

Establishment and testing of 'Area2D', a precision agriculture network for the South East of England, during May, June and July 2011

What is the project?

Precision agriculture relies on farm machinery having repeatable accuracy year on year. This can be achieved by the machinery being equipped with automated steering devices, and by using global navigation satellite system (GNSS) positioning technique and the networked real-time kinematic (NRTK) correction messages being received by GPRS mobile phone networks. Our project aims to increase the number of farms in the South East of England adopting precision agriculture, and establish and test the Area2D NRTK service.

What is the challenge your project addressed?

Current suppliers of the NRTK service charge annually in advance, with no price differentiation based on actual use, and the devices used are normally too expensive for farms smaller than 500 acres. This has deterred small farms adopting precision agriculture, or farms growing crops which have short growing seasons such as asparagus. Area2D can also improve accuracy in the horizontal plane, which suits agricultural users' needs.

What are the potential benefits?

Area2D aims to introduce pay-as-you-farm, an NRTK data service scheme, capped at the same level as the current annual subscription, so contract farmers will not be penalised for high usage, but small farms and light users will pay less. This should encourage greater adoption of precision agriculture in the South East of England, where there is currently an 8% adoption rate.

What are the next steps?

We believe it is possible to enlist over 500 users in the next 12 months, generating an annual turnover of £200k and a profit of £40k. Over the next five years, Area2D is expected to enlist over 2,000 farm machines from the UK's current 14,326 registered agricultural machines. This should provide an annual revenue of £800k and a profit of £150k.

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Galaxy Rose Systems Ltd

Galaxy Rose Systems has expertise in global navigation satellite systems (GNSS), global positioning system (GPS) timing and positioning, satellite navigation, space weather and GPS tracking.

Improved accuracy and integrity of low-cost global navigation satellite systems

What is the project?

Our project tests, under dynamic and challenging environmental conditions, a real-time ionospheric imaging system, which largely removes the ionospheric errors that arise in single-frequency global positioning system (GPS) solutions. GPS data is collected from on board a train and a car in challenging environments, for example in built-up city areas.

What is the challenge your project addressed?

Standard GPS positioning/timing solutions are inaccurate. They are susceptible to radiation originating from the sun. Every 11 years or so the radiation increases for about two-to-three years, which may severely disrupt GPS signals. This last occurred in 2001-2003 when GPS was not so widely employed. The biggest error in a single-frequency GPS solution is due to the ionosphere – part of the upper atmosphere. Our project aims to improve accuracy by reducing the ionospheric error.

What are the potential benefits?

The real-time imaging system allows for error corrections to be made and can lead to considerable improvements in GPS positioning and timing solutions. The technology has the potential to benefit all GPS users, particularly those with needs for highly accurate solutions, for example emergency services, governments, telecommunications companies, power distribution and generation companies, satellite navigation providers such as Garmin/TomTom, and banks. This could benefit the UK by providing jobs and producing exports.

What are the next steps?

We propose to carry out a further train study and to look into developing a product demonstrator.

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Helveta

Helveta provides technology to assure the origin and processing of tropical timber and agricultural products.

Carbon auditors – Helveta land carbon accounting system

What is the project?

Our project aims to support the effective management of forests and other land carbon assets in a cost-effective way to meet the current demand for land-carbon information and intelligence. Our feasibility study combines ground-based measurements with bio-mass models, which together raise the accuracy of the carbon stock measurements to more than 90%. This enhanced capability provides a foundation for accelerating initiatives in the management of natural resources and carbon stocks.

What is the challenge your project addressed?

REDD (the reduction of emissions from deforestation and degradation) presents a mechanism under which forests can generate revenue for the services they provide as standing carbon sinks, offering a viable alternative to the continuing practice of land conversion. Key to this mechanism is establishment of accurate systems to assess forest carbon so that the value of the services provided by tropical forests in climate-change mitigation are identified.

What are the potential benefits?

The benefits include an improvement in the quality and accuracy of REDD monitoring, reporting and verification systems, making REDD projects feasible on a large scale. This will ultimately lead to a reduction in deforestation and forest degradation and have a beneficial impact on global climate change.

What are the next steps?

Our next step is to further automate the process and mechanisms and to apply them to forests in the tropics.

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High Efficiency Heating UK Ltd

High Efficiency Heating was established 20 years ago and is a renewable energy technology installation specialist.

Identifying potential hydro installation sites on small rivers

What is the project?

Our study looks at the feasibility of establishing a new service to link satellite Earth observation technology to the identification of sites on small rivers where, despite the absence of obvious hydropower opportunity (for example a weir or dam), the installation of hydropower turbines might be viable.

What are the potential benefits?

Our service will increase market demand for hydropower, providing a boost to manufacturing industry and therefore to job opportunities. It would also help towards the targets on reduction of carbon emissions set by the Government and would simultaneously reduce our reliance on imported (and therefore vulnerable) fossil fuels. The service can be used world-wide and is therefore an export sale.

What is the challenge your project addressed?

There is an imbalance in the technologies deployed to assist the UK in achieving its goals on carbon-emission reductions and on the improvement of energy security. Hydropower is under-exploited in terms of the number of sites where it might be installed. At present, the complications of hydro installation on rivers are such that the industry remains somewhat under-developed. The challenge is to overcome those complications.

What are the next steps?

We believe the service can be ready for commercialisation within a year. We need to liaise again with turbine manufacturers, with hydropower installation specialists and the Environment Agency to precisely define the specification of service. We will then create a working model, a field trial and finally commercialise and promote to both the industry and also directly to markets worldwide.

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Logica plc

Logica provides business and technology service solutions to clients all over the world

UK Centre for Climate and Environmental Monitoring from Space (CCEMS) requirements analysis

What is the project?

To help satisfy a recommendation of the UK Space Innovation and Growth Strategy (IGS), we propose a national centre of excellence for climate activities, namely a facility for climate and environmental monitoring from space (CEMS), to be funded by both the private and the public sector. Our feasibility study outlines a detailed specification of user requirements of CEMS from the perspective of academic, commercial and government stakeholders, and provides a list of recommendations going forward.

What is the challenge your project addressed?

The challenge was to talk to a wide variety of stakeholders to understand our needs as a nation for access to and use of space data relating to the climate and the environment. The document clearly outlines the UK's needs and proposes the necessary ingredients for the CEMS facility.

What are the potential benefits?

The analysis, covering commercial, science and government interests, will allow us to target the needs of the national climate community. The CEMS facility aims to be financially self sustaining and, if realised, could enable us to satisfy recommendation six of IGS and make the UK a world leader in climate activities. It would also stimulate growth in the UK space industry, mainly from downstream applications.

What are the next steps?

The CEMS facility has support at very senior levels in the UK Space Agency, in industry and in the science community. Further funding would enable us to establish a system specification as well as a series of prototype services in a 'mini-CEMS'. This mini-CEMS would allow us to demonstrate the capability and potential of CEMS in a short space of time, maintaining the interest of stakeholders and hopefully attracting further investment.

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Logica plc

Logica is a business and technology services company, providing consultancy, systems development/integration, and outsourcing services.

GOVERNERS – Government network resilience via satellite

What is the project?

Our project aims to find a solution that would minimise the problems that could be encountered in the terrestrial network links (through wire and/or fibre) mainly due to sharing of ducts, cables and exchanges among the telecommunications companies and/or the Internet service providers.

What are the potential benefits?

UK public departments would gain from having a true diverse back-up link without having to rely on the terrestrial network. The adoption of this service by the UK public sector would help Avanti to export the solution to other governments, especially those within the European Union.

What is the challenge your project addressed?

Our GOVERNERS study examines how satellite communications could be integrated into UK government networks and sites to provide increased resilience and hence business continuity should the primary terrestrial connection fail. The study looks at the technical suitability of a specific satellite solution developed by Avanti Communications Group Plc, called the Business Internet Continuity (BIC) services.

What are the next steps?

We will continue to promote the capability using the material available and use the specific findings of this study to identify potential first governmental adopters. We will develop a proof of concept for one of the first adopters in order to validate the product and to showcase it to other users. We will also start the process of accrediting the scheme for governmental use, for example through the Government's CESG (Communications-Electronics Security Group) Assisted Products Scheme (CAPS) program.

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NSL is a global navigation satellite system (GNSS) application and technology developer operating across consumer, professional and government markets.

VULCANO – vulnerabilities and countermeasures within global navigation satellite system (GNSS) operations

What is the project?

GNSS technology is being embedded into many parts of our infrastructure. At the same time, GNSS vulnerabilities are being exposed and threats are increasing. Our VULCANO project analyses the vulnerabilities and threats to GNSS to arrive at recommendations for countermeasures and system testing to ensure continuity of GNSS can be maintained under degraded modes of operation or during a denial-of-service attack.

What is the challenge your project addressed?

VULCANO has examined a range of GNSS user communities and businesses, assessed potential threats to their operations, analysed their requirements for mitigation technology, identified candidate countermeasures and has delivered a draft test plan that will enable users to have confidence that their systems are resilient to those threats likely to affect them.

What are the potential benefits?

It is critical that private and public sector organisations responsible for procuring GNSS-based systems are aware of the vulnerabilities of GNSS, the potential threats and the economic consequences of denial of GNSS. Awareness of the threats, availability of effective countermeasure technologies and accessibility to a test regime, ensure that future procurements and investments in GNSS-based systems can be seen as resilient.

What are the next steps?

We have identified the most critical threats and the most promising countermeasure technologies for each sector and these will form the basis for new R&D activities to ensure the technologies are realised to meet the market demand. A draft test plan is now available for use by authorities, institutions and industry to support vulnerability assessments of GNSS-based systems and equipment.

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FLASHFIX

What is the project?

FLASHFIX aims to develop a new low-cost, high-security global navigation satellite system (GNSS) receiver for governmental applications. The FLASHFIX solution is based on using software-defined radio technology, which could reduce costs, increase flexibility and maintain the high levels of security. Potential applications are typified by requirements for resilience, robustness and reliability. Potential users include peacekeeping forces, border security, customs, crisis managers, law enforcers and those working in critical national infrastructure protection.

What is the challenge your project addressed?

The main challenge is to develop a new receiver product within the security domain where NSL is not recognised as a traditional supplier and software-defined radio is potentially a disruptive technology. This places high risk on the venture and requires a sustained commitment from NSL to achieve its target. FLASHFIX has focused on scrutinising all aspects of the technology and the market to develop the case for investment.

What are the potential benefits?

Market analysis by the European GNSS Agency suggests that 80% of public regulated service (PRS) users will be interested in 'low-end' applications, requiring low-cost GNSS receivers. However, current PRS receiver designs are expensive because of the security architecture. FLASHFIX has shown that use of our GNSS software receiver technology could reduce the cost of the low-end receiver, thereby addressing the needs of 80% of the PRS market.

What are the next steps?

FLASHFIX provides an opportunity for a sovereign Galileo PRS receiver capability for the UK. We are actively seeking interest, at all levels, from potential users, system integrators, defence contractors and institutions to support the development and validation of the FLASHFIX concept. A demonstrator FLASHFIX receiver exists, which is being trialled using Global Positioning System (GPS). Future versions will be trialled using simulation facilities in addition to real signals from Galileo satellites.

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ITERM – integrated navigation and communication terminal for integrated applications

What is the project?

Our project addresses the increasing need to combine satellite-based technologies with terrestrial systems and datasets to deliver integrated applications and services to professional and government users. ITERM is a mobile terminal based on the combined use of satellite navigation and satellite communication technologies. These satellite technologies are integrated with conventional terrestrial location and communications technologies to ensure that ITERM can provide seamless communications and position services irrespective of geographical location.

What is the challenge your project addressed?

Through working with the European Space Agency, NSL has identified a need for a multi-functional navigation and communication terminal that can be configured to serve a wide range of applications and projects. NSL has recently developed an integrated terminal (TITAN) for the rail market. ITERM provides the opportunity to enhance TITAN to include additional applications and services through the integration of new technologies, making it an attractive solution for major system development projects.

What are the potential benefits?

Our exploitation route consists of sales and support coupled with further project and contract work. ITERM will deliver benefits to a range of stakeholders. It will enable industry, developers and ourselves to experiment with different terminal configurations in order to trade off design decisions and optimise the technology choice for a given application. Furthermore, the European Space Agency (ESA), Technology Strategy Board and the International Space Innovation Centre will benefit from ITERM in terms of further promotion of the development of integrated applications.

What are the next steps?

There is a need to develop new partnerships with user groups to customise ITERM to individual requirements. Our team will also examine relationships with system integrators who can benefit from access to ITERM technology within large projects. There is also an opportunity to work closer with ESA to ensure that ITERM is used within the context of its Integrated Applications Promotion (IAP) initiative and the European GNSS Evolution Programme (EGEP) test beds.

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Roke Manor Research Ltd

Roke Manor is a world-class research and manufacturing electronics engineering company working with NPL, SEP Ltd and Psi-tran Ltd.

The integrated communications and navigation 'SpaceApp'

What is the project?

Our study establishes the feasibility of an integrated communications and navigation 'SpaceApp' for smartphones. With SpaceApp, multiple smartphones work cooperatively and seamlessly. Range-enhanced WiFi provides inter-satellite links. Precision relative position is derived from global navigation satellite systems (GNSS) or radio frequency (RF) ranging enhanced by multilateration. The SpaceApp and the smartphone are compact, power lean and low cost. It is the affordable answer for very small or larger satellite formation-flying and terrestrial 3D sensing.

What is the challenge your project addressed?

The challenge was to assess the feasibility of a smartphone app capable of communication and accurate ranging in space. The app needs to provide automated networking at up to 5Mbps over inter-satellite links from 1km-10 km for at least six satellites with 5W transmit power. A relative positioning capability is also needed within stated accuracies using the onboard GNSS, RF ranging and the smartphone camera or sun sensors.

What are the potential benefits?

SpaceApps on multiple smartphones meet a wide range of formation-flying space-mission requirements. The compact technology, low in mass, power and cost, can be very competitive for distributed aperture interferometers, two-spacecraft telescopes and rendezvous and docking. It can empower clusters of very small satellites to perform large satellite functions or offer cost-effective anti-collision management on larger platforms in congested orbits. Terrestrial spin-offs include 3D mapping, surveying and photogrammetry.

What are the next steps?

The Roke, NPL, Psi-tran and SEP partnership has the necessary skills to develop a baseline SpaceApp. We propose a partnership with SSTL for hardware integration and in-orbit demonstration. Our business plan is to adapt the baseline to other space and terrestrial applications in consultation with partners. We will seek institutional support to develop the baseline SpaceApp to leverage mission project or private funding for the wider range of space and terrestrial applications.

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Roke Manor Research Ltd

Roke provides innovative solutions and contract R&D capability, specialising in sensors, communications and information systems.

Evaluating Autoland for vision-based spacecraft rendezvous

What is the project?

Our project investigates the feasibility of using Roke's Autoland visual tracking system, developed for landing an unmanned aerial vehicle (UAV), to accurately determine the position and orientation of a target spacecraft in real time and enable automated rendezvous and docking using only a single camera. Tracking accuracy was measured by processing simulated imagery in a range of spaceflight scenarios. An investigation of the future work required to bring Autoland to the space market is included.

What is the challenge your project addressed?

A significant difference between terrestrial and space conditions of light is the lack of scattered/ambient light, which results in high contrast between lit and shadowed surfaces. The main challenges in this project were to assess whether Autoland could take advantage of these high-contrast edges, and to address the problem of tracking in low-light conditions, as would be the case for distant planetary exploration.

What are the potential benefits?

Autoland uses only a single camera to track its target, giving it mass, complexity and reliability advantages over tracking solutions based on light detection and ranging (LIDAR). This technology is crucial for 'sample return' missions, moreover its low cost and suitability for microsatellites could enable in-orbit service/inspection or missions to acquire space debris. The investigation of low-light conditions also has applications in terrestrial situations, including landing a UAV at night.

What are the next steps?

The next step for us is to test Autoland on real imagery of spacecraft rendezvous, or to develop a near-real simulation in partnership with experts in orbital mission design and space-based imagery. In the longer term, Autoland would be demonstrated on representative space hardware. We would attempt to get flight heritage on a technology demonstrator mission and the software would be developed to flight-code certification standards.

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Surrey Satellite Technology Ltd

SSTL provides low-cost access to space. Our partner CAL provides carbon auditing and assessment solutions.

Land carbon assessment and measurement project

What is the project?

Our study aims to establish and test a robust and scalable methodology for handling fine-resolution Earth observation data with allometric bio-mass equations to measure surface-level biomass and carbon asset measurement. DMCii, the subsidiary of SSTL, supplied ortho-rectified, geo-located satellite imagery to Carbon Auditors Limited (CAL) which used additional data from the US Forestry Service and Landsat to calibrate a statistical training model and perform biomass measurements.

What is the challenge your project addressed?

The carbon market is estimated to be valued at more than £30bn, and accurate measurement of carbon assets is necessary for accurate assessment of the financial value of activities such as carbon trading and to ensure carbon assets are properly managed in accordance with legislation. One of the challenges is to provide a cost-effective mechanism for retrieving and analysing carbon asset data, which is distributed abundantly across the globe.

What are the potential benefits?

Our study offers access to higher spatial and temporal resolution commercial carbon accounting. It demonstrates strong requirements for reliable data archives and regular data acquisition.
A number of related monitoring requirements have been identified, for example compliance monitoring, forestry stewardship verification and ongoing monitoring of protected areas. These other products are unavoidable outcomes of the production process and may be valuable if the revisit rate of the satellites is sufficient.

What are the next steps?

There is a need to refine and prioritise parallel development to ensure maximum value. Similarly there is a need to evaluate the justification for new satellite systems which should be procured to achieve the required level of service. The Canopy System (developed by Logica) should be developed to ensure product processing and provision in a manner suitable to the customer.

Spacecraft Components

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3-Cs Ltd develops process technology and designs for future superconducting electrical machines with unrivalled power density.

Dramatic size and weight reduction for power electrics in space applications

What is the project?

The feasibility and cost of missions in space is very largely dependent on payload, and the extreme power density of 3-Cs's superconducting technology is expected to dramatically reduce size and weight. Our aim is to demonstrate these benefits using a combination of experimental measurements on small, single-layer test structures and mathematical modelling to predict the performance of arrays of 3-Cs multilayer superconducting cylinders for superconducting magnetic energy storage (SMES) and ion thrusters.

What is the challenge your project addressed?

Our technology is at an early stage of development despite the existence of a pilot plant to fabricate coated conductor cylinders. While the necessary up-scaling is being carried out, only small-scale demonstrations are possible, and therefore modelling is necessary to extrapolate the performance of arrays of patterned multilayer cylinders of the future. Potential applications being considered in the space sector are energy storage and ion thrusters.

What are the potential benefits?

Space missions will be cheaper and more feasible as a result of the dramatic size and weight reduction predicted by the modelling. If successfully commercialised, our technology will be implemented across a wide range of market sectors including energy, aerospace/defence, transport, and medical imaging (MRI). To take one example, MRI is a £5bn-a-year global industry. Six jobs have been created so far but this could grow to hundreds or thousands in the future.

What are the next steps?

We need to promote awareness of this high-power density 'platform technology' across a range of sectors. Space applications were prioritised because of the unique capability of 3-Cs's continuously coated superconducting cylinders in applications requiring 'persistent mode' (as used in MRI). We wish to collaborate with larger players in the space sector, for example UK Space Technology Centre, and the European Aeronautic Defence and Space Company, to obtain European Space Agency funding, with the help of the Technology Strategy Board.

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Astrium Ltd

Astrium is the number-one space company in Europe, employing 2720 staff in the UK.

Carbon fibre tape-springs for self-deploying large structures

What is the project?

The ability to deploy large spacecraft in orbit will enable a host of new space missions, from very long baseline X-ray and gamma-ray telescopes, to large radar arrays for Earth observation. The tape-spring hinge is a key element of our new deployable structure technology, so the focus of this project is to characterise and model such springs in collaboration with Leeds University.

What is the challenge your project addressed?

The detailed behaviour of tape-spring hinges during deployment is little understood. This project aimed to establish how the hinge torque changes with deployment angle for both single and multiple hinge configurations, and for a number of different carbon fibre constructions. A non-linear finite element model of the tape-spring hinges was also developed, which will be correlated with the experimental data in order to better understand this key technology.

What are the potential benefits?

Understanding the behaviour of tape-spring hinges will significantly assist in developing our new self-deploying spacecraft structures, which have the potential to open up a new market within the space industry. Deployable structures are recognised by the European Space Agency (ESA) as a key development for future missions in space science and Earth observation, improving the capability of space-borne instrumentation. This will be the first such technology available in Europe.

What are the next steps?

Following the development of the tape-spring hinge component of our self-deploying structures, we will construct a representative breadboard which will aim to raise the technology readiness level (TRL) of the complete structure to five. This will ensure that the technology is a suitable candidate for ESA missions in the near future, particularly in the science sector for long baseline telescopes in high-energy astrophysics.

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Astrium Ltd

Astrium UK is a world-leading supplier of satellite systems, space transportation and services.

Embedded resistive and capacitive layers within printed circuit boards

What is the project?

Our project investigates the feasibility of embedding resistive and capacitive layers within printed circuit boards (PCBs). This could provide several significant advantages to the manufacture of PCB assemblies.

What are the potential benefits?

The potential benefits are reduced component cost; increased reliability; decreased PCB size; increased yield; a requirement to hold less stock.

What is the challenge your project addressed?

The main challenges have been to determine the overall approach to ensure the technology is useful. To successfully adapt this technology, other cutting edge technologies such as ‘stacked microvia’ are also required.

What are the next steps?

If suitable funding can be found, we plan to increase the technology readiness level of the technology to one suitable for flight.

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EADS Innovation Works

EADS, through Airbus, Astrium, Cassidian and Eurocopter, provides leadership in aerospace, defence and related services.

ALAMOSS – Additive layer manufacture of satellite structures

What is the project?

Our ALAMOSS project assesses the feasibility of applying additive layer manufacturing (ALM) to the production of structural parts for Astrium satellites. By comparing the technical requirements of spacecraft structure to the current ALM state-of-the-art material (including a breakthrough EADS proprietary alloy), we made a technical gap-analysis. We selected a strut bracket to validate by structural test the ALM process against a machined baseline and against a topology optimised design that would save weight and further cost.

What is the challenge your project addressed?

There has been a significant gap in technical knowledge in the application of ALM to spacecraft structure. An opportunity existed to take learning from other Technology Strategy Board projects relating to fixed wing structures and rapidly mature ALM for spacecraft structures. Our project assessed the feasibility of this technology transfer, which, until now, has been held back by a range of unanswered questions. ALAMOSS has been successful in delivering this rapid increase in technology readiness.

What are the potential benefits?

Production of telecommunications structures at Astrium is forecast to increase by 50% to six per year in the short to medium term. Assuming a 50% cost reduction in the production of brackets, this would give a cost saving of £750K annually if all were produced using ALM. There are also other advantages that are not immediately tangible, such as mass and material waste reduction, resulting in an improved environmental life cycle to the product.

What are the next steps?

We have mapped out further rapid development to technology readiness level (TRL) six. EADS Innovation Works and Astrium have sufficient internal capability to progress the activity to the stage of qualification, certification and flight. In the long term, EADS would seek to develop a means of securing a supply of parts to support industrialisation.

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ITM Power

ITM Power was established in 2000 and its 55 staff develop and sell prototype electrolysers and fuel cell systems.

Very-high-power-density fuel cells for space study applications

What is the project?

We have developed novel ion-exchange polymers for use in electrochemical cells. These have proved to operate at exceptionally high power densities as fuel cells with hydrogen and oxygen inputs, achieving power densities of more than 5.5W/cm^2. The same class of materials has also been developed into electrolysers which produce hydrogen and oxygen from electricity and water. Such systems offer significant opportunity for weight and volume reduction, and the feasibility project investigates the market opportunities.

What is the challenge your project addressed?

The feasibility project aims to establish whether our fuel cell materials could help to achieve smaller and lighter energy conversion devices for deployment in space applications. The challenge was to identify the key criteria for space applications, to examine our ability to meet these and to identify potential market areas for future exploitation.

What are the potential benefits?

The study has shown that our membrane materials could bring size and weight reductions in space applications. It has also identified applications where proton exchange membrane fuel cell (PEMFC) opportunities are relatively advanced and hence offer greater potential for implementation. The satellite market is forecast to grow considerably in the near future and the UK is investing large sums. We believe our technology can help to lower satellite mass and volume requirements and hence lower costs.

What are the next steps?

PEMFCs are an experimental technology so immediate commercialisation is not expected. It is clear that, in order to further develop our high-power-density materials for space applications, an experimental development program will be necessary. It is also clear that we would require expert partners in a number of areas, including stack design, thermal and water management, gas storage and experience with space applications.

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Keronite International

Keronite offers an advanced surface treatment for light-alloy components deployed in demanding environments.

Black inorganic coatings for satellite (Bicosat)

What is the project?

Our project studies the feasibility of using an environmentally friendly process for the production of black coatings on high-volume silicon-carbide-containing aluminium metal matrix composites (Al-MMCs) to achieve good thermo-optical and tribological properties for use in high-value optical instruments and satellite components, for example satellite barrels, sun sensor housings and space baffles. The coatings have been evaluated in terms of coating formation, quality, structure, environmental resistance, colour spectrum and thermo-optical properties.

What is the challenge your project addressed?

Al-MMCs with up to 40% silicon carbide are of interest for use as structural materials due to higher modulus-to-weight ratio, stiffness, fatigue strength and greater thermal stability compared to wrought counterparts. Anodising of Al-MMCs is difficult and does not meet multifunctional and stringent environmental requirements. The plasma electrolytic oxidation (PEO) process which allows the formation of black coatings on these alloys will enable engineers to design lightweight space components with multifunctional properties while meeting stringent environmental standards.

What are the potential benefits?

The novel black PEO coating could lead to Al-MMC lightweight components with improved performance in terms of corrosion, fretting wear, cold welding and stable thermo-optical properties, while giving significant savings on weight and launch costs. It is estimated that 1kg weight reduction of a satellite can save approximately £30k-50k of launch costs while a satellite launch can cost anywhere from £30m-250m.

What are the next steps?

Further funding of up to £250k will enable us to scale up the Keronite process to coat full-size components which the European Space Agency would be expected to use. With this funding, we could design and manufacture prototypes using a finer grade Al-MMC. We are also actively looking for further collaborations with ESA, Astrium and UK Space Agency to help us develop and test the solution, for example sending prototypes to the International Space Station.

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Magna Parva Ltd

Magna Parva was founded in 2005 and is a provider of science and technology services and technologies.

Manufacture of large space structures

What is the project?

In this study we assess the feasibility of using pultrusion – a proprietary, patented technology for manufacturing materials – for the manufacture of large structures in space, integrating sensors, electronics and actuators into the pultruded sections and then assembling the sections into larger structures.

What are the potential benefits?

The change from deploying systems in space to manufacturing them in situ will make a big difference. Structures built in orbit are more mass efficient than those constructed on Earth. The size and shape of structures manufactured in orbit is not determined by the dimensions of the launcher used to deliver the materials, allowing the design of very large structures.

What is the challenge your project addressed?

The increasing cost of launching into space means any technology that enables larger structures to be used will benefit space applications, for example a manned Mars mission where it is impossible to launch pre-manufactured infrastructure cost-effectively. Space manufacturing will have to become the norm and it is our long-term aim to position the UK in the forefront of this technology.

What are the next steps?

The European Space Agency's acceptance of our Innovation Triangle Initiative (ITI) proposal will allow the demonstration of the viability of in-flight manufactured space structures by means of a breadboard model pultrusion unit. The breadboard will help development of the technology and encourage support for the project once viability is proven. The development work will strengthen the UK network created during this feasibility study, with new parties potentially getting involved.

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Oxford Technologies Ltd

OTL are experts in remote handling for hostile environments.

Universal lightweight robot tool exchange

What is the project?

Our study aims to design and build a lightweight robotic arm tool exchange for evaluation on a space technology test bed. The tool-exchange interface comprises two halves, one of which is permanently attached to the robotic arm, and another that is permanently attached to each of the tools. When fully engaged, the halves are latched together and electrical power and signals can be transmitted.

What is the challenge your project addressed?

This study has shown the feasibility of a lightweight robot tool-exchange mechanism. Commonly used interface devices for robotic tool exchange rely on high positional accuracy of the robot and tools. The aim of this study is to design an interface that tolerates a less structured environment and that will automatically align to accommodate a high degree of misalignment.

What are the potential benefits?

The device is aimed at promoting the UK small and medium-sized enterprise (SME) space sector as part of the European Space Agency's Aurora programme. Successful development will be applicable to markets in nuclear fusion and medical robotics. We are committed to developing equipment for rehabilitation markets. This innovation will be directly applicable to these markets in applications where grasping objects is a requirement. OTL expects to recruit two-to-three people within the next 12 months to address these markets.

What are the next steps?

We will continue to work with Astrium (UK) Ltd to develop the tool-exchange technology for applications related to the space sector. We need to develop the reliability of the system and to address the material compatibility and light weight necessary for space applications. This study provides an opportunity for us to seek further funding to develop the technology for use in other markets.

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Reliance Precision Ltd

Reliance is an established specialist engineering company providing high-reliability, precision electro-mechanical assemblies and components.

European gearbox for space applications

What is the project?

Preliminary market investigations suggest that satellite mechanism manufacturers in Europe are highly dependent on the US for the supply of electro-mechanical assemblies, such as gearboxes. The European Space Agency has set a strategic target for all European satellites to contain a minimum of 50% European-sourced components. Our project investigates the opportunity for a UK-based design and manufacturing company to provide products into the European space market.

What is the challenge your project addressed?

We have a reputation for excellence in geared mechanisms in the aerospace market. The challenge is to identify the market opportunity, technical requirements and investment costs involved in entering the space market, specifically to understand the technical requirements unique to space, the development roadmap and the qualification process. We understand that small and large suppliers have previously found the investment requirements in relation to market return too great and have withdrawn from space.

What are the potential benefits?

A new European market entrant, once qualified, could offer not only the benefit of reduced unit costs to the satellite industry, but also reduced through-life costs as a result of having a local, readily accessible source of supply. Having a small or medium-sized enterprise as that source of supply also affords greater flexibility in terms of offering custom design and manufacture rather than off-the-shelf products.

What are the next steps?

The accessible market for the specific type of assembly investigated in this project could be in excess of £4m. Because of the way Europe's space development funding is managed and the importance of developing products in line with the European Space Agency's harmonisation strategy and qualification process, the most critical next step is to secure a route into an ESA programme, with support from the Technology Strategy Board and UK Space Agency.

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Robosynthesis Ltd

Robosynthesis was established in January 2009 and is a specialist in proprietary robotics systems.

Applicability of Robosynthesis modular robotics system for planetary exploration

What is the project?

Ultra-modular robotics, which we have developed, is a reconfigurable, scalable robot platform designed to be adapted to self-reconfiguration. It is at the pre-industrialisation stage for commercialisation into defence, security and utilities markets. Our study looks at how the application of the core system could be extended to space and related extreme environments

What are the potential benefits?

The key benefits of the technology are multi-functional applications achieved by adaptation; condensable payloads; avoidance of single-point failure; a rapid development platform; and self-reconfiguration to perform specific tasks and self-optimisation for given operating conditions. Further operational, planning and logistical benefits arise from the above.

What is the challenge your project addressed?

The project will provide parameters for future development of planetary rovers. The study will assess the key challenges for the modular system in space and the key parameters for enhanced, self-adaptive all-terrain mobility obtainable from the reconfigurable and self-reconfigurable system.

What are the next steps?

The next steps will include developing variant topologies and kinematics readily obtainable by reconfiguration of the modular system, variant methods of locomotion, self-adaptive topology and kinematics obtainable through self reconfiguration, and trajectory control. The wider strategic aim of the project is to establish a future R&D framework for the technology.

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RolaTube Technology

RolaTube manufactures extendable composite masts used in communications applications, the energy industry and civil engineering.

Lightweight deployable mast for space exploration

What is the project?

Our project develops and tests a prototype deployable mast of high-torsional stiffness and a deployment mechanism based on new material combinations and assembly/processing techniques developed by RolaTube. Testing for space applications will be carried out by Astrium. We aim to create the template for a product range for a new market sector, not a laboratory prototype, so the project includes development of a viable manufacturing methodology.

What is the challenge your project addressed?

Relatively low torsional stiffness, or resistance to twisting, is a factor that has limited RolaTube's bistable reeled composite technology in applications where significant loads have to be prevented from twisting at the end of an extended arm. Further development is required to reach the levels of torsional stiffness at high extensions required for applications such as sensor and camera deployment, widening the field of application for this innovative UK technology, particularly in space exploration.

What are the potential benefits?

This innovative technology could be used in such applications as the lightweight Mars Rover currently being studied at the concept level by Astrium for the European Space Agency (ESA). There are direct applications to autonomous vehicles for lightweight deployable stiff masts for cameras. There are further military and civil opportunities in RolaTube's current market for extended camera deployment and precision location applications.

What are the next steps?

We plan to develop the technique with a range of tube diameters; shrink the current deployment mechanism to fit a smaller tube; incorporate a 'deploying' top guide; test the lifetime of the bond under cycling and different environmental conditions, and investigate alternatives if required; and market development within both space and terrestrial applications. We are hoping to maintain the partnership with Astrium and the ESA ExoMars project.

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RolaTube Technology

RolaTube manufactures extendable composite masts used in communications applications, the energy industry and civil engineering.

Bistable carbon-fibre-reinforced plastic masts for solar arrays

What is the project?

Our project develops deployable masts using flight-heritage materials for space and a simple deployment mechanism for their extension. These are used to deploy a flexible solar panel that is stored around a carbon-fibre-reinforced plastic (CFRP) drum – a very light and compact solution for power generation in space that is attractive to the small-satellite community. The concept is scalable so that larger satellites could benefit from it as well.

What is the challenge your project addressed?

We use a wide range of fibres for our Bistable Reeled Composites (BRCs) but the resin matrix used has always been thermoplastic as the manufacturing process can then be simpler, reducing overall costs. The manufacturing process of BRCs with a space-qualified thermosetting matrix, such as an epoxy or a cyanate ester resin, is more complex and additional engineering design will be required to achieve the bistable effect on the new masts.

What are the potential benefits?

The technology developed during the project will open new markets and opportunities for RolaTube. The evolution of BRCs from Earth to space applications could lead to new contracts, such as through the European Union FP7-SPACE calls. These masts can be used on a wide variety of large space-deployable structures, such as dipole antennas, antenna reflectors, sun shades, solar sails and drag-deorbiting devices.

What are the next steps?

The techniques learnt from this study will be applied during our participation in the FP7 DEPLOYTECH project, administered by Surrey Space Centre. Further work is planned on this class of product with Surrey Space Centre, and we plan production to become a routine, albeit lower volume, process, in line with our current thermoplastic product range.

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Systems Engineering and Assessment Ltd

SEA specialises in providing systems engineering and specialist design solutions to government agencies and industry.

Plasma buoyancy demonstrator feasibility study

What is the project?

Our project is the first step in the development of the innovative concept of plasma buoyancy. This is a technology which could lead to the evolution of lighter-than-air vehicles by replacing the traditional balloon envelope with an electro-magnetically confined plasma. The project successfully advances the theory, and includes a study of the market potential and the development of a demonstrator, which is currently being built.

What is the challenge your project addressed?

The challenge was to advance the concept with help from two Rutherford Appleton Laboratory plasma experts and to then design a demonstrator that would test the assumptions and prove whether the system is capable of lifting payloads. Relationships were created between the size and energy of the plasma and the mass and energy of the containment system for a given payload, and they will be tested.

What are the potential benefits?

The replacement of traditional balloon envelopes with a confined plasma offers a number of potential benefits including no vulnerability to tears and holes; reusability; increased endurance; possibility of reaching even higher altitudes; and greater practicality in the storage and launch. In the long run, plasma buoyancy is intended to assist with satellite launching and the exploration of planets and moons with atmospheres.

What are the next steps?

The next step is the completion and testing of the demonstrator, which is expected shortly. When the results are available, we can take decisions on the future of the technology, with the next steps being a detailed plasma simulation and larger scale demonstrator. If the development is successful, we would look to form a technology development consortium with other UK aerospace companies.

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Systems Engineering and Assessment Ltd

SEA specialises in providing systems engineering and specialist design solutions to government agencies and industry.

Wireless power and data transmission for spacecraft ground testing

What is the project?

Our study looks at the business case for wireless power and data transfer for use during assembly integration and verification (AIV) on missions to planets covered by planetary protection. It looks at the performance of the various data and power options, at a sufficiently detailed design to establish a development plan, and at assembling a business case for the technology in the spacecraft systems integrator market.

What is the challenge your project addressed?

The challenge was to provide power and data wirelessly across a plastic interface of about 1mm in thickness. For power transfer, this entails splitting a transformer core between primary and secondary windings, which takes transformer design in an unusual direction and requires careful design to cope with higher-than-usual-leakage magnetic field. The interface will undergo dry heat sterilisation during AIV – and this requires that the design can survive 30 hours at 125 degrees centigrade.

What are the potential benefits?

The benefits include providing simplifications to AIV, specifically the ability to test equipment when still in sterile bags. This lowers the AIV activities required. People do not have to work in an ISO 7 grade-B facility and the electrical ground support equipment/harness does not need to be brought into the clean facility, and hence does not need to be compatible with it. This could lead to an overall reduction in the cost of a mission.

What are the next steps?

We need to take the business case forward and present it to the major spacecraft integrators so there is wider understanding of the advantages of the wireless technology. We also need to continue the development of the technology, through building breadboards and developing the data bus field-programmable gate arrays (FPGAs) or integrated circuits. We can then move towards fully operational systems.

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SSBV Space & Ground Systems

SSBV SGS designs and manufactures subsystems for small satellites and has a worldwide customer base.

Enhanced reaction wheel development for small-satellite applications

What is the project?

We currently have one reaction wheel product to offer the market. Reaction wheels are devices that aim a satellite in different directions. We have had requests for wheels of different specifications but we have not had the resources to investigate expansion of the product range to capture a larger market share. This feasibility study allows new product offerings to be explored including larger, smaller and radiation-hard (hi-rel) reaction wheels.

What is the challenge your project addressed?

In the space market, heritage of design is one of the most important considerations for customers. The challenge was to evolve a higher performance wheel using as much of the current design as possible. Likewise, reducing the size of the units had to be achieved with the minimum of electronic component changes. Finally, an investigation was undertaken into the replacement of electronic parts with hi-rel parts.

What are the potential benefits?

The intention of this study was to allow us to choose where the internal R&D resource should go to achieve the best return on investment. The larger wheel design appears best suited to the current market conditions, so we will move ahead with detailed designs, manufacture and qualification of this product. The long-term benefit is in increased exports, growth and employment.

What are the next steps?

We will now undertake detailed mechanical design and analysis, printed circuit board layout, building of a prototype, and qualification testing and marketing. The main target export markets are the USA and Asia.

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SSBV Space & Ground Systems

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Novel attitude sensor for small-satellite applications

What is the project?

Our study investigates a novel sensor that can determine the direction of spacecraft travel in all orbital locations by measuring the pressure or density of the atoms and ions that a spacecraft moves through in low Earth orbit (LEO). The project brings together our attitude sub-system design knowledge and the expertise of the plasma physics team at the Mullard Space Science Laboratory (MSSL), part of University College London (UCL).

What is the challenge your project addressed?

Simple, low-cost, attitude control systems rely on sun sensors and magnetometers to generate the two vectors required to give unambiguous knowledge of the direction in which the spacecraft is pointing. Problems arise during eclipse periods when the sun is lost. What the market requires is a simple, low-cost, low-mass/power sensor which measures a second vector during an eclipse. Measuring the spacecraft direction of flight is one way of achieving this.

What are the potential benefits?

The development of a low-cost sensor that can provide attitude information during an eclipse, with minimal resources from the spacecraft platform, will enable a reduction in cost, complexity and size of LEO missions and consequently enable a new generation of applications to be developed based on these space assets at a significantly lowered cost of entry. This could include small constellations of communications, navigation or Earth observation satellites.

What are the next steps?

We have demonstrated the technical feasibility of the system. We need a prototype sensor, qualification testing and in-orbit demonstration to bring the sensor to market. We plan to raise awareness by presenting the concept at international conferences.

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Thermacore Europe Ltd

Thermacore Europe designs and manufactures advanced cooling systems for high-end electronic devices.

Next-generation heat pipes for thermal management in space

What is the project?

Highly efficient cooling systems are required in space applications where heat dissipates by radiation only. To transport heat away from the electronic components to the radiators, axially grooved heat pipes are commonly deployed. In this project, we investigate a novel manufacturing technique and prototype next-generation aluminium heat pipes that will enable a step increase in thermal performance over the current technology.

What is the challenge your project addressed?

Copper heat pipes deployed in terrestrial applications use a sintered porous medial capillary structure that allows surface heat fluxes of 50W/cm^2. As lightweight aluminium heat pipes cannot be easily sintered using conventional manufacturing techniques, an axial grooved capillary structure is deployed allowing surface heat fluxes of approximately 5W/cm^2. The manufacturing technique investigated allows a 3D computer-aided design (CAD) geometry to be used to manufacture sintered-style aluminium capillary structures.

What are the potential benefits?

Increased performance of aluminium heat pipes allows for higher packing densities of the electronics and potentially a reduction in the number of heat pipes required, thereby allowing the overall mass of the system to be reduced. In addition, as the effect of gravity on sintered heat pipes is less than that on grooved heat pipes, the requirement for the heat pipes to be horizontal during ground testing could be eliminated.

What are the next steps?

We need more in-depth thermal and mechanical testing of the current prototypes followed by a more in-depth research and development project to develop the prototype designs into commercial devices. A specific European Space Agency grant has been identified that may fund this research. To increase the technology readiness level (TRL), an actual device must be supplied to an end user for ground testing.

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Thermacore Europe Ltd

Thermacore Europe designs and manufactures advanced cooling systems for high-end electronic devices.

Polymeric heat pipes for space applications

What is the project?

Next-generation miniature satellites with deployable radiators require a flexible thermal joint between the electronics and the radiator. Our project aims to develop suitable polymers that could be used to construct lightweight flexible heat pipes that may be coiled for launch and are easily routed through the electronics enclosure to provide a direct thermal connection to high-heat-flux components.

What are the potential benefits?

Polymeric heat pipes offer a weight reduction over metal heat pipes, but the major benefit is vastly reduced materials and manufacturing cost. Our project has allowed the major challenges to be addressed, but further work is required to perfect the techniques and take them from the laboratory to commercial processes.

What is the challenge your project addressed?

Many lightweight flexible polymers are available, but high permeability results in the rapid loss of vacuum within the heat pipe, producing very short operational lifetimes. Fluorinated polymers offer the lowest permeability, but they are hydrophobic, leading to interaction issues with the working fluid. Our project investigates production of an impermeable gas layer and surface treatments to create hydrophilic surfaces.

What are the next steps?

Thermacore and the University of Cambridge continue to collaborate and build on the work carried out in this project. As more successful barrier layers are developed, we will initiate parallel research to address the minor challenges in developing polymeric heat pipes to allow the transition to a commercial product.

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ThinkTank Maths Ltd (TTM)

TTM is a mathematics innovation company creating game-changing solutions in space, energy, defence and finance.

Trusted reasoning architecture for autonomous spacecraft control

What is the project?

Future space exploration and commercial applications of satellite constellations will require higher levels of spacecraft autonomy than is possible to achieve using traditional control systems. In this project, we assess the feasibility of applying our trusted reasoning architecture (TRA) for autonomy – originally developed in the defence sector – to spacecraft control. The TRA has the potential to overcome many of the shortcomings of current control systems.

What is the challenge your project addressed?

In future missions such as ExoMars and the European Space Agency (ESA) Cosmic Vision programme, spacecraft will perform mission-critical tasks on their own without direct human supervision. Uncertain planetary or space environments may involve sudden, disruptive events like component failure. To adapt, future spacecraft need to go beyond the simple rule-based behaviours used by current systems. They require an autonomous ability to reason and make decisions about unexpected changes.

What are the potential benefits?

A flexible, reliable autonomy solution for spacecraft control would bring significant value to the space industry. A market size of tens of millions of pounds over the next two decades is a conservative estimate. Our novel approach to safety-critical control systems also has a number of cross-sector applications, from assisted living to the nuclear industry. The outcome of the feasibility study will help us to demonstrate the value of TRA to prospective partners.

What are the next steps?

We aim to develop long-term collaboration and partnerships with prime contractors and the ESA.

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ARGANS Ltd

ARGANS was established in 2007 and specialises in remote sensing and software engineering in marine, atmospheric and terrestrial environments.

Development of innovative non-spherical particle modelling tools to support Earth observation instrument and observation qualification for climate change services

What is the project?

Our project investigates the feasibility of applying 3D Finite-Difference Time-Domain (FDTD) numerical techniques implemented on Graphics Processing Units (GPUs) to modelling the optical properties of non-spherical particles. This supports the development of improved 3D radiative transfer light modelling, including the quantification of uncertainties. Two models – light scattering behaviour in water bodies and volcanic ash clouds – were used with code developed from proof of concept to a beta-level software tool.

What is the challenge your project addressed?

The accuracy of many important Earth and atmospheric observation technologies is compromised because they are based on the assumption of energy interactions with only spherical particles. The FDTD method is well established, but puts an unmanageable demand on computer processing power. ARGANS' in-house code leverages the parallel processing power of GPUs to enable solution times up to 60 times faster. This substantially improves the feasibility of applications that require ensemble model runs.

What are the potential benefits?

The polarisation of directional scattering is simplified for perfect spheres, and applying polarimetry to non-spherical particle scattering is a potentially rich source of information that could be exploited by new sensors and/or techniques. Whilst developed in a marine context, the model is generic and potential atmospheric applications have become clear in consultations with the National Physical Laboratory (NPL), a partner in the study providing important end-user advice.

What are the next steps?

We will retain this in-house capability in our commercial portfolio. Further research collaboration and industrial partners are required to develop its full potential. Increased awareness of this expertise by potential customers and collaborators will stimulate collaboration and develop joint onward research and business funding opportunities. We intend to seek out such opportunities through the Technology Strategy Board, UK Space Agency, European Space Agency and others as part of our on-going business development plan.

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BAE Systems

BAE Systems are manufacturers of bespoke microelectromechanical systems (MEMS) devices.

Radically miniaturised particle energy spectrometer as a demonstrator of the utility of high-aspect-ratio microelectro mechanical systems (MEMS) in space components

What is the project?

MSSL manufactures spectrometers for space. We are working with MSSL to design a MEMS spectrometer that will be much smaller than existing spectrometers. Such instruments will provide a technology leap, leading to considerable savings and making them especially attractive for future small satellites, constellation missions and scientific/planetary missions.

What are the potential benefits?

This spectrometer potentially has massive advantages over current spectrometers. It is much smaller and much lighter than existing designs and can be produced at lower cost.

What is the challenge your project addressed?

The design was not too difficult mechanically but there were electrical challenges. This is a high-voltage device with multiple contacts and interconnects. Eventually, we arrived at a design that should work.

What are the next steps?

A MEMS spectrometer has successfully been manufactured. Following testing there is a very real possibilty that this prototype device could be launched on a satellite. In the future, we would like to extend the process to include a MEMS lid on the existing design, fabricate design variants within the existing process to demonstrate and deliver ‘tuneable’ performance, incorporate design improvements, and also look to establish new processes for alternative designs.

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Bartington Instruments

Bartington Instruments designs and manufactures high-performance fluxgate magnetometers and magnetic susceptibility measuring instruments.

Space-flight qualification for low-noise gradiometer (to measure magnetic fields)

What is the project?

Bartington makes sensors for the space industry to use on the ground for checking magnetic cleanliness of satellites. We have had requests to make sensors suitable for space flight but have lacked the resources to develop a sensor using space-compatible components and materials. Our project was to gain experience of designing, building and testing for space flight and hence the confidence to bid for space business in future.

What are the potential benefits?

As a result of this project we have a real product which we can market to potential customers, and the knowledge to design a bespoke sensor to meet the specific requirements of space projects. This opens a new and valuable market to us, potentially a 3% increase in business. The enclosure, made locally, and testing at Rutherford Appleton Laboratory Space all benefit the Oxfordshire economy.

What is the challenge your project addressed?

There is a limited range of components and materials suitable for use in space. We had to adapt our electronic circuit, change the materials used in our fluxgate design and design a suitable enclosure. We then checked that the sensor performed to specification and passed the stringent testing for vibration and operation in a vacuum that is required for space flight equipment.

What are the next steps?

We will use our own funds to do some production engineering on the basic design to make it suitable for manufacture. Staff will be trained to certified space-grade assembly standard. We will market the magnetometer created during the project as a way of attracting business from commercial satellite manufacturers and organisations such as the European Space Agency.

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Innovative Small Instruments Ltd

Innovative Small Instruments develops solutions for process industries including robotic vision and autonomously controlled remote sensing instrumentation.

Robotic eye for autonomous navigation and object recognition

What is the project?

Our project investigates merging two competing technologies – light detection and ranging (LIDAR) and a stereo camera – to create a new class of 3D imager. We investigate the technical feasibility and assess the potential of this new sensor to meet the main challenge of creating a flexible, low-cost enabling sensor for wide application across a variety of industries including autonomous navigation of rovers, aerobots and robots for airports, industrial and surveillance environments.

What is the challenge your project addressed?

Working with the Mullard Space Science Laboratory (MSSL), the challenge is to produce a new class of eye-safe sensors generating accurate real-time 3D information. The key challenge is to balance computer processing capability with the throughput demand of the data sensors to provide a high density of accurate 3D data in a timely manner. Area-matching stereo images provide excellent data but processing takes time; LIDAR is fast but does not provide the same level of data. By merging these technologies within both the hardware and software, together with other data fusion, optimisation should enable 3D production within several seconds instead of hours.

What are the potential benefits?

Robotic navigation is a key enabling technology for planetary exploration. This harsh environment mimics 'in-building' scenarios for obstacle avoidance. Our sensor aims to solve navigation problems to enable new robotic industrial porters to work in hostile environments, airports, hospitals and industrial facilities. Low-cost robust 3D sensors have potential for increasing the use and adoption of robotic navigation, allowing greater mobility in everyday life and improving the quality of life for an ageing population.

What are the next steps?

In partnership with production companies and industrial users, we plan to develop new algorithms and implement the key concepts investigated. We need to conduct two key tasks – the modification of stereo camera matching software to enable better use of the LIDAR data and allow individual sub-image stereo-pairs to be processed in parallel to speed up the reconstruction of 3D images; and the exploration of hardware and different programming techniques to improve the speed of scientific code to enable industrial applications.

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OpTIC Glyndŵr

OpTIC specialises in designing, developing and manufacturing metre-class precision optical and opto-mechanical components and systems.

Light-weighting facility for space optics

What is the project?

Our project looks at the feasibility of OpTIC Glyndŵr providing a cost-effective light-weighting capability in response to the requirements of the UK satellite industry. The growing small-satellite and space-instrumentation-systems markets increasingly require cost-effective rapidly producible highly polished light-weighted mirrors. Light-weighting and polishing are interconnected processes because of the risk of structural features causing print-through onto the polished surface.

What is the challenge your project addressed?

The challenge has been to develop a machining process that produces optics of requisite quality and light weighting, whilst being compatible with subsequent treatments and capable of being used in our manufacturing facility.

What are the potential benefits?

We are now able to light-weight optics by more than 70%, and provide a one-stop service in the UK for light-weighting and polishing of high-performance optics. Previously, the generation of light-weighted features has been reliant on expensive processes at overseas glass foundries with long lead times or has had to be outsourced to separate suppliers, thus adding risk of incompatibility and damage.

What are the next steps?

We are now marketing a light-weighting capability alongside our other optics machining and opto-mechanical design services. We look forward to being of service to our customers old and new.

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Systems Engineering and Assessment Ltd

SEA specialises in providing systems engineering and specialist design solutions to government agencies and industry.

Cooled bolometry (measurement of radiant energy) for cloud ice radiometry

What is the project?

The role of ice clouds in affecting the Earth's total radiation budget is one of the key uncertainties in the area of climate modelling. Cryocooled (involving extreme cold) detectors, which have been developed within the UK for astronomy missions, are now sufficiently mature and at a sufficiently high technology readiness level (TRL) to warrant an investigation into their viability as an alternative to the more traditional approaches.

What is the challenge your project addressed?

The project defined an instrument concept to meet the science requirements for cirrus cloud monitoring, based on the existing detector technologies developed by Cardiff University, and the existing cryocooler technologies developed by Rutherford Appleton Laboratory. The resultant instrument, although relatively high-power, was shown to offer a significant improvement in radiometric precision over existing approaches, with no significant TRL gaps.

What are the potential benefits?

The precision achievable through cryocooled bolometry significantly improves the ability to perform cloud-ice imaging. This improves the accuracy of future climate models. The UK is already strong in the various required component technologies – cryocooling, sub-millimetre wave instruments, bolometric detectors and precision mechanisms. This development could therefore give the UK a strong export position for low-volume, but high-value space instruments and complementary airborne instruments.

What are the next steps?

We will seek funding for the three possible development strands. These are a low-cost breadboard demonstrator of the cooling chain and electronics; an airborne experiment to extract high-performance data in the sub-millimetre wave band; and a phase-A study to further refine the instrument design.

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Clyde Space

Clyde Space is a leading developer and supplier of small spacecraft systems.

Low-cost, off-the-shelf, modular de-orbit system for small spacecraft

What is the project?

Useful low-earth orbits are becoming increasingly congested and there is a real possibility of future legislation requiring all new spacecraft to have an inbuilt de-orbit and disposal system. An aerobrake deployed using stored-strain energy will increase drag, decelerating the spacecraft so that it re-enters low-earth atmosphere and burns up. Our project aims to investigate the potential market, define the technology, and then prototype a demonstrator for a realistic system.

What is the challenge your project addressed?

Previous work on the de-orbit concept has focused on the use of electric motors to achieve deployment of the aerobrake. Unfortunately, this concept assumes that the spacecraft is still operational and has enough power, and it introduces added complexity, weight and space requirements. We have demonstrated that electric motors can be eliminated and that aerobrake deployment is achievable using strain energy stored in the spacecraft structure itself.

What are the potential benefits?

A de-orbit system for small spacecraft will have a positive impact on the near-earth environment by providing a low-cost method of reducing space debris, increasing safety by reducing collision risk, and making orbits available for other spacecraft. Furthermore, a cheap de-orbit capability will permit more flights of spacecraft that would otherwise not meet disposal guidelines. This project has defined a system architecture that we fully intend to commercialise.

What are the next steps?

Having achieved proof of concept, the next stage is to produce a prototype from space-compatible materials to confirm that such a system will perform as well as the current design under test in the laboratory. We need to do further work to fine-tune the folding and attachment of the aerobrake membrane to the deployable structure that has been developed.

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Clyde Space and Ecometrica

Clyde Space is a leading developer and supplier of small spacecraft systems. Ecometrica is an ecosystem services specialist.

Bushfire mitigation using nanosatellites

What is the project?

Bushfires are damaging to valuable ecosystems and property, present a real threat to human life, and have a significant economic impact. Our project investigates the use of a nanosatellite constellation, equipped with dual-band thermal-imaging cameras, to provide a fire early-warning system (FEWS) for detecting and tracking early-phase bushfires from space. The system would need to be of relatively low cost to be commercially viable. Two mission concepts were studied.

What is the challenge your project addressed?

The primary challenge was to combine the sensor and satellite platform in a cost-effective manner that could still provide timely commercial data. Initial ideas looked at a stand-alone FEWS constellation of nanosatellites but it was concluded that it would be preferable to use the FEWS constellation as an extension and enhancement of the European Space Agency/ German Aerospace Centre FireBIRD mission. This symbiotic concept would aid in increasing the potential market worth of the data.

What are the potential benefits?

The primary potential benefits of timely and accurate bushfire warnings are clear – preservation of human life, ecosystems, property, commodities such as commercial crops and forestry, and utilities such as electricity and telecommunications links. Secondary benefits include the study of bushfire dynamics, community planning, fire prevention and fire statistics (‘burn histories’).

What are the next steps?

We need to do further work on successful miniaturisation of the sensor scanning mirror and testing/benchmarking of the overall sensor system. A clear ‘route to market’ for mission data products needs to be clarified, potentially through collaboration with the FireBIRD team. Additional work on identification of potential customers is ongoing, particularly within the financial commodities and insurance sectors, which sit outside the more obvious initial customer base of forestry and agriculture.

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Clyde Space and UK ATC

Clyde Space is a leading developer and supplier of small spacecraft systems. UK ATC develops astronomical instruments.

CubeSat camera for low-cost digital planet mapping

What is the project?

Our project investigates the feasibility of using a constellation of low-cost, rapidly-deployable nanosatellites (CubeSat standard), equipped with high-resolution electro-optical ground-imaging equipment, to give timely access to any point on the earth's surface at less than 10m ground sampling distance in the visible and near-infrared colour spectra. This capability would support disaster relief, environmental monitoring, conflict monitoring and resolution, and other beneficial activities, creating wealth and meeting public sector needs.

What is the challenge your project addressed?

CubeSats capable of precise pointing for long periods of time, and optical instruments with substantial deployed elements, are novel in the small satellite industry. Therefore, our project addressed two main challenges – downsizing the optics of a high-resolution imager system to fit the confines of a CubeSat spacecraft; and the precise and accurate pointing of the imager payload on board.

What are the potential benefits?

Beneficiaries of a successful system would range from government departments through commercial news broadcast companies, to national security organisations and non-governmental organisations fulfilling humanitarian relief or environmental monitoring roles. The proposed low cost of building and deployment opens the capability to users who have previously been excluded from space due to high cost. The uses of such a capability are limited only by the imagination.

What are the next steps?

We are working to define the initial potential customer base, investigate other possible uses for the system, develop camera concept designs, summarise the current available electro-optic and attitude control system technologies, and look at the impact of emerging technologies on current limitations. The next phase of the project is to develop a prototype product and conduct further targeted market research.

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EADS Innovation Works

EADS Innovation Works develops innovative solutions in the areas of mobility, security and the environment.

Additive layer manufactured propulsion for multifunctional CubeSats

What is the project?

Our project is a feasibility study between EADS IW and the University of Surrey into the application of novel manufacturing methods to spacecraft propulsion system design, development and manufacture. Work on platform and system requirements, followed by various thoughts on design led to the development of a prototype design suitable for initial evaluation. The project shows that the rapid turnaround of additive processes can accelerate design evolution and enable optimised development.

What is the challenge your project addressed?

The CubeSat was developed to enable academic development of spacecraft. The evolution of miniaturised components has led to the development of increasingly ambitious missions, which can struggle with the extreme mass, volume and power constraints associated with CubeSat design. This project aims to consider the use of novel manufacturing techniques to enhance the capabilities of the CubeSat platform by including a propulsion system that minimises mass and volume.

What are the potential benefits?

The use of additive layer (ALM) methods to manufacture a propulsion system, integrated into the chassis of a CubeSat, would transform the range of missions possible with the platform. The integrated nature of the design offers extensive flexibility on nozzle placement, making a three-axis-controlled CubeSat a real possibility. Demonstration of the rapid turnaround nature of additive techniques could also provide opportunities for applications on board larger, more expensive satellite platforms.

What are the next steps?

We plan to conduct a detailed stress analysis of the current proposal, followed by detailed propulsion system design and identification of suitable valve components. This will result in the development of a metallic demonstrator, suitable for initial testing under representative conditions to characterise performance. Further industrial collaboration will be required, together with public funding support, to balance the associated risks of applying ALM to this new area.

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Logica plc

Logica is a business and technology service company that has been providing space services for more than 30 years.

Android as a platform for space missions

What is the project?

Our study looks into the development of an advanced space-based software test bed.

What is the challenge your project addressed?

Our study addresses two problems – the cost of developing on-board software and the availability of a software test bed in space to flight-prove innovative on-board software solutions. Advanced concepts for payload data processing, such as image processing, compression or autonomy systems, exist but can only be flight proven in exceptional cases. This stifles innovation. The emerging Consultative Committee on Space Data System (CCSDS) Spacecraft Monitoring & Control (SM&C) standard provides the required monitoring and control service definitions, but has yet to be flight proven.

What are the potential benefits?

Both Logica and SSTL see a large financial potential in the developed solution, establishing UK companies as a leading on-board software innovator. Discussions with both a UK University (Surrey) and the advanced concept group at the European Space Agency show a clear interest in an on-board software test bed in order to demonstrate and flight prove innovative on-board software.

What are the next steps?

We need to gain funding for implementation of the necessary elements. There could be some internal funding and some funding from SSTL, and there will be a need for external funding. We need to establish a community of parties interested in testing onboard software solutions so we can define the development and runtime environment. We then need to implement the SM&C application programme interface (API), implement the onboard data API, create an online community site and define working procedures for the validation and scheduling of experiments.

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MESL Microwave

MESL designs and manufactures microwave and electronic components and subsystems for telecommunications, defence and space.

Radio frequency (RF) section development of an S-band transceiver for use in CubeSat

What is the project?

The European Space Research and Technology Centre (ESTEC) has identified European CubeSats as a growth area but has also identified a lack of high-data-rate transceivers as a limiting factor for professional use. Transceivers operating in S-band can fill this gap. In this feasibility study, we investigate the RF design of an S-band transceiver and include the manufacture of a potential receiver chain.

What are the potential benefits?

The CubeSat concept allows a much lower cost of entry for new space products, meaning universities and small enterprises can test products in space at a reasonable cost. This could lead to significant innovative product developments for institutions which would otherwise have discounted the space market. A high-data-rate S-band transceiver developed by us could increase the general capability of CubeSats.

What is the challenge your project addressed?

Our aim is to develop a transceiver that offers professional range data rates of more than 100kbps with power efficiencies that are compatible with state-of-the-art space batteries. Design constraints imposed were size restriction; restriction to commercial off-the-shelf components; minimum DC power consumption; and frequency scheme selection to avoid spurious signals.

What are the next steps?

We plan to design and manufacture a direct conversion receiver including the interface to the digital section of the receiver; design and manufacture the transmitter section; and integrate them to form a combined S-band transceiver. The successful completion of these steps will require partnerships with others in the CubeSat market. We have already begun informal collaboration with two such companies.

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Red Skies Technology Ltd

Red Skies Technology is a software and electronics development company providing solutions to the space sector.

Study to demonstrate a prototype flight computer built with commercial off-the-shelf technology

What is the project?

Our project aims to develop a rocket/missile flight computer and sensor suite built around the .NET Micro framework and demonstrate a data feed. It aims for transmission of feed at 868Mhz band to ground control, ground control display of feed using Windows Presentation Foundation (WPF), relay of feed to remote server over Windows Foundation Classes (WFC) service, recording of feed into an SQL server database management system, relay of feed to registered client machines, and rendering of feed on a client device.

What is the challenge your project addressed?

By developing a complex end-to-end system using popular commercial off-the-shelf technology, we set out to demonstrate the potential to more cheaply and reliably develop systems while encouraging manufacturers in other sectors to look at the provision of solutions to the space sector. Using technologies such as WPF, Silverlight and WFC we were able to quickly develop and demonstrate a system that could integrate with any .NET software.

What are the potential benefits?

Using off-the-shelf hardware and software frameworks, development times for certain systems can be reduced and overall reliability increased. Such systems can be standardised more easily, can integrate with third-party systems more naturally and can be developed more safely across various teams due to a shared awareness of standard components and software. With more companies able to provide development services, new jobs and wealth can be created.

What are the next steps?

We will continue to develop a number of separate systems based on technologies developed for the demonstration. These include an Azure-based feed manager to allow unlimited feeds from unlimited sources and companies to be managed and published either privately or publicly; a Silverlight visualisation software feeding from gyro, Global Positioning System (GPS) and other sensor feeds; and continued work on flight computer as well as research into remotely programmed and managed resilient .NET CubeSat.

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SciSys UK Ltd

SciSys was established in 1980 and specialises in software solutions across a broad market including space.

CubeSat on-board software generation

What is the project?

Our project sets out to establish and then demonstrate that a plug-and-play approach to the development of embedded on-board software for CubeSats could be realised by following the design principles and rigours of a service-orientated architecture. The envisaged solution would be manipulated using reusable software components within a development environment to construct a software system that is directly deployable onto the on-board CubeSat computer.

What is the challenge your project addressed?

CubeSats represent a potential shift in the development of space missions and their future services. Designers approach these systems using standardised components. However, their on-board software is currently limited and this in turn restricts mission ambitions. As mission needs evolve in operational complexity, it is uncertain if the on-board software can be similarly standardised to fit the CubeSat model and yet offer enhanced, robust and reliable in-orbit performance.

What are the potential benefits?

Our approach offers a set of simple and re-useable on-board software functions that can be easily configured and tested. Designing and implementing the mission software then becomes a process of selecting and configuring a set of standard services, extending them where necessary to perform specialised processing. The associated demonstrator established by our project opens up a new dialogue between software and CubeSat systems teams.

What are the next steps?

We will use the demonstrator to establish on-board software mission needs with designers and target those missions that take full benefit from our approach. We will work with designers to better understand their choices and the interfaces to the various CubeSat subsystems. We will then join with others to develop a concept of end-to-end operations for the mission and link this to service delivery and our business proposition.

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STAR-Dundee Ltd

STAR-Dundee is an engineering R&D company formed in 2002 which specialises in spacecraft on-board processing and data-handling technology.

SpaceWire-Nano: low-power, high-speed, deterministic interconnect for nano satellites with plug-and-play capability

What is the project?

Nano-satellites require a means of interconnecting instrument, sensor and actuator boards to the main spacecraft control computer. This must be low-power and in a small footprint (number of connector pins and wires). Currently there are several different interconnects used on nano-satellites but all are limited by low data-rates to save power. There is a requirement for a standard interconnect for future nano-satellite developments that delivers high speed at low power.

What is the challenge your project addressed?

Our feasibility study aims to bring the advantages of SpaceWire spacecraft network technology to nano-satellites without impacting adversely on mass and power budgets. This was achieved using an innovative technique interconnecting a stack of circuit boards in a nano-satellite using SpaceWire. Additionally, the advances and extensions to the SpaceWire implementation to solve the nano-satellite requirements have addressed issues that have thus far limited SpaceWire technology to non-critical data transfer.

What are the potential benefits?

The major benefit is the provision of a standard interconnect for the nano-satellite sector that promotes compatibility between equipment across manufacturers. A standard interconnect reduces development costs, improves reliability and, most importantly, increases the level of science that can be achieved within a limited budget. The SpaceWire implementation that facilitates adoption within the nano-satellite sector should allow critical data functionality to use SpaceWire, opening the wider aerospace and avionics industries.

What are the next steps?

Having successfully manufactured the prototype system, we need to do further development to complete the testing and fully prove the design concept. This will result in a demonstrable prototype to support the marketing of the new technology. We will self-finance this remaining work.

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Steepest Ascent

Steepest Ascent provides next-generation embedded and communications technologies to the aerospace, defence and telecommunications markets.

High-performance embedded computing CubeSat subsystem

What is the project?

CubeSats provide an innovative, low-cost platform for accessing space. A need exists for improved on-board processing capacity that would allow pre-processing of data to maximise the available downlink bandwidth. Our project investigates the viability of developing a high-performance embedded computing (HPEC) subsystem using commercial off-the-shelf components. An architecture and directory of suitable parts has been compiled, including level of susceptibility to the space environment, test information and flight heritage.

What is the challenge your project addressed?

Current CubeSat on-board computers or processing subsystems are basic at best and not suitable for any large degree of on-board processing. Payloads that require a large degree of processing are mainly custom designed and have minimal reuse. An HPEC platform would look to address this issue and provide not only the processing base to a single payload but also potentially a shared central processing resource for a number of payloads.

What are the potential benefits?

Providing multiple processing platforms to a single satellite would lead to a significant revenue opportunity for us. All satellite markets, including Earth observation, environmental monitoring and communications, would benefit from this development. Without the study, the possibility of investigating the application of in-house advanced signal processing and communications in a new technology field such as satellite embedded system design would not have been possible.

What are the next steps?

We are poised to seek further funding to apply and implement the feasibility study findings. However, one of the obstacles faced by new product developers within the space industry is flight heritage. Gaining access to a test flight would be beneficial to the future of the HPEC product. We will pursue both funding and a test flight.

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Steepest Ascent

Steepest Ascent provides next-generation embedded and communications technologies to the aerospace, defence and telecommunications markets.

CubeSat S-Band transceiver

What is the project?

CubeSats are an innovative and low-cost platform used increasingly within Earth observation and environmental monitoring applications. However, as CubeSat applications increase in complexity, greater demands are being placed on the downlink bandwidths. With high-resolution sensory data placing strain on the downlink capabilities and an absence of a capable uplink to allow in-flight updates to be performed, there is a need for the development of a high-speed S-band transceiver.

What is the challenge your project addressed?

Our project identifies the characteristics of and requirements for a CubeSat S-band transceiver. It models a complete end-to-end CubeSat/ground station communications link, including link budget losses and gains and the base transmission scheme incorporating all physical layer aspects such as encoding/decoding, modulation/demodulation and receiver synchronisation. The system developed is used to achieve performance metrics for various low-earth-orbit CubeSat and ground station configurations.

What are the potential benefits?

To date, nano-satellite mission objectives have focused on high-speed downlink data transfer, resulting in a handful of S-band transmitters developed by universities. No commercial, high-reliability, high-speed CubeSat transceivers currently exist within the market and the S-band transceiver envisioned by us is therefore considered unique. The significant growth of the CubeSat market and need for such a payload represents a significant revenue opportunity for us.

What are the next steps?

We are now in a position to seek further funding from sources such as Scottish Enterprise or the European Space Agency to apply and implement the feasibility study findings. Two key objectives must be achieved for further development to happen – a suitable partner, capable of providing the RF front-end design capabilities needs to be found, and a joint application for further funding, between ourselves and a partnering company, must be formulated.

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Surrey Satellite Technology Ltd

SSTL is the world's premier manufacturer of small satellites and associated technology and services.

Exploitation of microsatellites for CubeSat technology demonstration and launch

What is the project?

Our project is in two parts. The first studies the accommodation of CubeSat avionics modules and payloads on board TechDemoSat in a CubeSat avionics and payload accommodation module (CAPAM), and develops this module to a level which demonstrates its feasibility and indicates the potential mass budget, number of CubeSat modules and data throughput. The second part is a feasibility study into a CubeSat deployment via microsat system (CDVMS) launch system for CubeSats from TechDemoSat.

What is the challenge your project addressed?

The TechDemoSat (TDS) programme will offer several flight opportunities to UK industry and academia over the coming years. A significant section of industry and academia in the UK are developing CubeSat technologies. It will be highly beneficial to UK industry to be able to accommodate CubeSat hardware and/or CubeSats themselves on board TDS satellites and to take advantage of the qualification opportunities afforded by access to the TDS programme.

What are the potential benefits?

The CAPAM enables the incorporation of CubeSat technologies into future TDS and SSTL missions. The development of the CAPAM leverages university expertise, and enables a more comprehensive and cohesive national space technology development strategy. The Surrey PicoSatellite Orbital Deployer (S-POD) concept developed as a result of the CDVMS activity has a global potential market. It has substantially better performance than rival offerings and will allow CubeSat developers to fly significantly more capable payloads.

What are the next steps?

The CAPAM is now specified such that detailed design and prototyping can occur. We will seek additional funding for this. The collaborative STRaND-1 mission between the University of Surrey and SSTL provides a route to test the technology, albeit deploying directly from the launch vehicle instead of from a larger platform. Under internal investment, a prototype S-POD is now being developed and will be qualified later this year.

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VEGA Space Ltd

VEGA Space is an expert in consulting, technology development and engineering services for space agencies, satellite operators and manufacturers worldwide.

Global educational network for satellite operations (GENSO) for International Space Innovation Centre (ISIC)

What is the project?

Our study investigates the feasibility of a global network of low-cost ground stations to support the emerging market for low-cost satellite missions. It aims in particular to support the integration of S-band ground stations with missions such as UKube-1. We are in a strong position to do this because of our key roles with the European Space Agency (ESA) in ISIC and the GENSO project.

What are the potential benefits?

A network of ground stations will allow future satellite missions to be designed with less constraint from the communications bottleneck. It will enable low-cost satellite missions, including those undertaking environmental monitoring, and will stimulate development of innovative technology and growth of this new industry. Jobs will be created in the operation of a commercial global network of low-cost satellite operations.

What is the challenge your project addressed?

The data return from a satellite mission is limited by the time the satellite is in range of its ground station(s) and by the communications data rate. The current generation of low-cost satellites typically have one ground station per satellite, with communications in VHF/UHF bands. The contact time could be increased through a network of ground stations, whilst the data rate could be improved by using higher frequency bands.

What are the next steps?

We need to further develop the software technology to manage a reliable global network of low-cost ground stations, and introduce service-level agreements. This may be done through supporting new and existing experimental and educational missions, including UKube-1, in collaboration with ESA and the GENSO project.

Disclaimer

The entries in this directory were provided by the individual companies. The Technology Strategy Board cannot guarantee the accuracy or completeness of any of the information about the winning projects.

The Technology Strategy Board is a business-led executive non-departmental public body, established by the Government. Its role is to promote and support research into, and development and exploitation of, technology and innovation for the benefit of UK business, in order to increase economic growth and improve quality of life.

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