→ GSTP
ANNUAL REPORT
2013
Contents

→ 20 years of GSTP .............................................................................................................. 4

→ Summary of Achievements & Challenges

GSTP achievements in 2013 ................................................................................................. 7
GSTP developments initiated in 2013 .................................................................................. 10
GSTP market-oriented activities: A.O. initiated and closed in 2013 ................................. 14
When space goes microscopic ............................................................................................ 16
Proba-V ................................................................................................................................ 18
OPS-SAT .............................................................................................................................. 20

→ Annexes

Annex 1: List of GSTP Documents to the Industrial Policy Committee (IPC) .................. 25
Annex 3: Complete list of GSTP activities initiated in 2013 .............................................. 27
Annex 4: Complete list of GSTP activities closed in 2013 ............................................... 28
GSTP CELEBRATES 20 YEARS DEVELOPING TECHNOLOGY.

Born in 1993, in response to the need of increasing European efforts in developing technology in order to face the rising complexity of European Space Missions, the GSTP has grown and matured. Over these 20 years, GSTP has demonstrated itself as a key and successful programme, recognised by the Participating States as one of the best instruments in ESA to promote innovation, enable National and ESA missions and strengthen the competitiveness of European industry.

During the last two decades, the GSTP has successfully bridged the gap between having a technology proven in fundamental terms and making it ready for ESA and National Programmes, the open market and, eventually, space itself. Some good examples are the LEON family of microprocessors flown in AlphaSat and baseline in the Sentinels, the technology predevelopment done for the CFRP reflector of the Plank Telescope, the GPS POD instrument baseline in the Sentinels and Earth Care missions, the MEMS rate sensor flying in Cryosat 2, the 1N “green” thruster in PRISMA, the APS development that led to the lightweight Star Tracker in BepiColombo or the hybrid low cost magnetometer in ADM-Aeolus. Also worth to mention is the Thrust Vector Control system of our small European Launcher VEGA or the Human Spaceflight related activities like the gas monitor Anita, the Melissa project and the Point of Care Diagnosis and other health monitoring devices for astronauts.

The GSTP develops technology concepts into engineering models and converts them into a broad spectrum of mature products—everything from individual components, to subsystems, up to complete satellites. A relevant example of GSTP flight opportunities to demonstrate technology is the PROBA (Project OnBoard Autonomy) satellite series, the SMOS Instrument MIRAS or the technologies demonstrated on-board the ISS like the Automated Identification System (AIS).

Always looking ahead, the GSTP is now helping to prepare the future of space: green propulsion, additive layer manufacturing, Clean Space, electric propulsion, Big Data, Ka-Band for data downlink, ECS-CC, etc. These are only some of the new challenges being addressed by GSTP that will enable the European missions of the future.
**GSTP OBTIVES**

- Enabling missions of ESA and national programmes by developing technology
- Fostering innovation by creating new products
- Strengthen the competitiveness of European industry
- Improve European technological non-dependence and the availability of European sources for critical technologies
- Facilitate spin-in from outside the space sector

**THE GSTP SERVICE DOMAINS**

- Earth Observation
- Science
- Human Spaceflight and Exploration Preparation
- Space Transportation and Re-entry Technologies
- Navigation
- Generic Technologies and Techniques
- Space Situational Awareness
- Robotics Exploration

**PARTICIPATING STATES**

- Austria
- Belgium
- Czech Republic
- Denmark
- Finland
- France
- Germany
- Greece
- Ireland
- Italy
- Luxembourg
- Netherlands
- Norway
- Poland
- Portugal
- Romania
- Spain
- Sweden
- Switzerland
- United Kingdom
- Canada

---

**SMOS - MIRAS**
The Soil Moisture and Ocean Salinity mission launched in 2009 makes global observations of soil moisture over land and sea-surface salinity over the oceans.

**GPS POD**
Precise Orbit Determination Swarm, Sentinels and Earth Care missions.

**VEGA TVC**
Thrust Vector Control subsystem of the VEGA small European Launcher 1st Launch in 2012.

**GIOVE Test Receiver**
In support to GALILEO mission.

**MEMs Rate Sensor**
CrySat 2 launched in 2010.

**ANITA**
Analyzing Interferometer for Ambient Air Trace gas monitor on ISS.

**SCOC3 system on a chip**
Spacecraft controller already flight proven and selected for several ESA and non-ESA missions.

**AIS on ISS**
Space Based Automatic Identification System receiver brings worldwide sea traffic tracking within reach.

**Hybrid Low cost Magnetometer**
Baseline in ADM-AEOLUS. Launch planned in 2015.

**Nodding Mechanism on ISS**
Positioned in the Station's Cupola to support a camera in taking high-definition pictures.

**Non-conventional materials**
Non-conventional matrix/carbon nanotube skeleton reinforced composites.

**ETP - Energetic Particle Telescope**
Flying in PROBA V, records the charge, energy and angle of incoming charged particles along a broad range of energies across a wide 50° field-of-view.

**PROBA 3**
First precision formation flying mission. Two spacecrafts separated by 150m will be used as a solar coronagraph to study the Sun's faint corona. Launch planned in 2017

**OPS-SAT**
Operation’s Satellite. Launch planned in 2016.

**GAMIR**
First Galileo Space Receiver
Additive Layer Manufacturing

**Challenges for the Future of Space**
Clean Space, Big Data, Electric Propulsion, EGS-CC, Ka-Band for data downlink

---

**GSP Annual Report 2013 | 7**
SUMMARY OF ACHIEVEMENTS & CHALLENGES

Making a launcher thrust chamber.
GSTP ACHIEVEMENTS IN 2013

ADVANCED SLIP-RING SOLUTIONS
With the participation of Austria and Germany

The development of advanced slip-rings for space applications require reliable and robust technologies compatible with high power density and harsh environment for Solar Array Drive Assemblies. The transfer of high electrical power through rotary joints reached the limits offered by current technologies, materials and design solutions.

In this activity, the overall objective was to identify, select, develop and test a series of advanced contacting slip-ring technologies compliant to requirements defined for spacecraft: in particular in terms of capability for high electrical power transfer with minimised losses, robustness in operation and isolation concept, low electrical noise contacts and integrated sensors for position control.

Many technologies have given full satisfaction in terms of cost, handling, and physical properties. Different process, material and components were tested and assessed achieving major improvements in terms of minimization of losses, electrical power capacity, noise levels and robustness.

GSTP aims at ensuring the right technologies at the right maturity level are available at the right time. In 2013, 41 activities were completed achieving the technology developments originally targeted.

CRYOSTAT TECHNOLOGY DEVELOPMENT FOR ELECTRODYNAMIC HEAT SHIELD
With the participation of Germany

The thermal power received from the surrounding atmosphere that a spacecraft has to withstand during planetary entry is certainly one of the most important and cost driving factors for the design of hypersonic vehicles. The electrodynamic-heatshield concept is based on the idea of avoiding the technological limitations of traditional material-based thermal-protection systems via the exploitation of electromagnetic fields which, in principle, can influence the flow of electrically charged gas mixtures such as those that flow hypersonically around the nose region of a re-entry spacecraft. Interactions between such flows and the electromagnetic fields should result in a reduction of the thermal power delivered to the spacecraft.

As part of the Electrodynamic Heat Shield (EDH) program, the objectives of the EDH Cryostat activity was to develop hardware utilizing an electromagnetic heat shield for reentry purposes. The breadboard cryostat was designed and built in order to perform the qualification and flight representative shaker test of a superconducting coil in the defined cryogenic environment. The hardware passed several primary tests. Some weak points of the primary design was discovered and improved. The hardware is ready for the further vibration tests to verify the manufacturing methods of superconducting coils.
The interest in the development of multi-element multi-frequency Terahertz (THz) cameras with high image and spectral resolution technologies is their inherent spatial resolution, their ability to penetrate through non-metallic objects, their spectral identification capabilities, and their sensitivity to moisture. These systems will find wide-spread use in both space and terrestrial applications. Interesting examples for space application include bonding flaw detection of the thermal insulator foam on tanks of launchers, topographic information of the surface quality of antenna reflectors, benign versus hazardous dust/particle detection for space exploration, “all-weather” visibility in dust storm conditions on Mars, etc. For terrestrial applications, the fast screening and stand-off detection and identification of concealed objects and substances is considered of major interest.

Initially the objective was to develop a multi-frequency active raster scanned terahertz radar for stand-off materials characterization and build a laboratory demonstrator, which in the future could be upgraded to pre-industrial system or to flight level. However, in the frame of the activity it was decided to change the imager concept from an active radar to a passive imager having the capability of detecting terahertz radiation in three distinctive frequency channels (“three-colour imager”) keeping some spectroscopic capabilities. The centre frequencies of these channels were 250 (“red”), 450 (“green”) and 720 GHz (“blue”).

In the ESA STIR project, the passive three-colour stand-off imager was built and tested. The passive “colour” imaging was chosen, because of several technical reasons. As passive, there are no population health concerns that would arise if illumination of the target would be used (i.e. active imaging). Besides, the multi-frequency imaging can enable better detection statistics, increased operation robustness and potential for materials differentiation (spectroscopy). This concept is also capable of producing real-time or near real-time video of the target covertly and non-intrusively. Spatial and temperature resolutions are good enough to provide possibilities, like object recognition, beyond mere anomaly detection.

After further technical testing and software development, the commercialization of the STIR stand-off type imager is planned.

A Schematic diagram of the passive three-colour imager.
HIGH SPEED TUNABLE LASER INTERROGATOR FOR SPACECRAFT HEALTH MONITORING

With the participation of Ireland

The availability of reliable flight sensor data and the knowledge of the structural behavior is essential to the safe operation of the spacecraft (satellites, launchers, probes) and is key to do continuous optimization of design, test, and operation. Fiber optics sensing techniques are seen as one possible approach that can improve the reliability of the monitoring system or facilitate additional measurement points without adding to the costs and mass and could enhance the overall safety and reliability of the launch vehicle. The development of a robust interrogator is seen as a key requirement to expand the applicability of the fiber optic sensing approaches.

The objectives of this activity were to design, manufacture, and demonstrate a multi parameter fibre optic sensor interrogator suitable in form fit and function for launcher applications based on the use of tunable laser diodes and validated it in a representative laboratory relevant environment. This activity resulted in gaining a vast understanding of the launcher environmental conditions that will result in the design of a flight model fibre sensing solution in terms of functionality, form and fit. The Vx development platform demonstrated the mitigation techniques to overcome the vibration and thermal effects, along with the design of an anti-aliasing filter, polarisation mitigation, dynamic power budgeting of the laser, and birefringence effects on the fibre cable while maintaining absolute sensor accuracy, and high sensor data acquisition.

BIOCHEMICAL ANALYZER TECHNOLOGY (BIOCAT)

With the participation of Germany

Biochemical analysis is gaining importance to detect molecules in very low concentration. The potential domain of applications are found in the Civilian Security and Welfare protection area like Aircrafts, hospitals and factories for the detection of harmful chemicals or organic molecules. The link to research in space is also obvious for its use onboard ISS or to further analyse life biomarkers on Mars and in planetary exploration.

For the ISS, a system can be built based on current well-mastered biochemical measurement techniques and test kits. Bioanalysers for planetary missions are considered, and special adaptations to interplanetary conditions are required for the measurement technologies, reagent handling and reagent conditioning.

The objectives of this activity were to upgrade the developed BIOCAT technology enabling detection of very low concentrations of mixtures of molecules (at Pico molar level or below) and single cell organisms in aqueous solution and on solid support. The aim was also to define sampling and sample conditioning technologies for the samples to be analysed with BIOCAT.

During the BIOCAT study several methods for the identification of typical discussed biomarkers were analyzed for their detectability by means of fluorescence measurements: autofluorescence of biomarkers and detection of biomarker classes (protein, nucleic acids, cell wall compounds) with biomarker class-specific dye-mediated fluorescence.

Selected BIOCAT design concept.

Optical test board (tunable laser, etalon filter) during mechanical testing.

BIOCAT housing.

Miniaturized fluorescence detectors: The miniaturized optical detector has the key function within the BIOCAT system. It is a high performance optical detector with light weight (60g), small volume (60ml), low power consumption (+5VDC) and robust design (no moving parts).
The development history of spaceborne laser transmitters has clearly identified the need for a pressurized housing. Up to now no qualified model of a large transmitter in sealed design has been reported. To secure the full applicability of new technologies for future laser missions as well as other sealed over-pressure housing configurations, it is required to demonstrate their complete space qualification status.

A pressurized housing for high power laser in space requires several types of feed-throughs for electrical, optical and thermal purpose, mounted in a sealed, pressure resistant housing. For this application, special attention has to be paid on the choice of materials used to avoid the risk of contamination due to outgassing.

The objective of this activity is the qualification of a pressurized housing including several hermetical feed-through building blocks as well as the relevant mounting and sealing technologies.

Within this project, different qualification breadboards will be designed for qualification testing. These breadboard concepts will be optimized by use of thermal and structural simulations, ending in designs suitable to demonstrate the adequacy of the specific technologies, processes and used components.

### 16-BIT ADC

Today there is no suitable space solution in Europe for high speed (e.g. 20Msps) and high resolution (16bit) Analogue-to-Digital Converters (ADC) to process and digitalise analogue output signals from image sensors or other high resolution instruments. Such devices should enable new applications with higher performance. Additionally, this development would guarantee European independence and would reduce the dependence on COTS devices and their associated costs and time.

The objective of this activity is to design and test a standalone high speed (20Msps) and high resolution (16-bit) ADC. The primary use of this device will be for CMOS image sensors and also potentially for any generic analogue signal data acquisition e.g. CCD image sensors. Several new types of atomic clocks with better performances and requiring larger number of simultaneous high-resolution control channels will require high resolution ADCs. Onboard atomic clocks are one of the key elements of GNSS systems that could be considered for use in high resolution instruments for Earth Observation, Space Science and Secure Telecom Applications.
With the participation of Norway and Sweden

Today most Earth Observation (EO) satellites use isoflux antennas operating in X-band for data downlink. The X-band bandwidth is currently heavily occupied by EO satellites and such as low gain antennas seem to be not adequate for the next EO missions currently requiring data downlink rates of 1Gb/s or higher, the Ka-band (between 25.5 and 27 GHz) being their preferred baseline.

Ka-band suffers from higher propagation losses than the traditional X-band. These losses can be compensated through use of steerable antennas that provide higher directivity than the traditional isoflux antennas as well as different locations of the Ground Stations to ensure data downlink every orbit via Ka-band.

The objective of the Mechanically Steerable Data Down Link Antenna (MSDDA) is to design, develop and test a steerable ITAR free Ka-Band Antenna (KBA) through representative environmental and lifetime tests of the required antenna pointing performance and reliability under flight conditions.

The Antenna Pointing Mechanism (APM) being developed consists of two Small Rotary Actuators (SRA) arranged in elevation over azimuth configuration. Both SRAs are supported by the APM structure L-bracket.

The K-band reflector antenna is connected to the elevation stage via the antenna bracket. In addition the antenna provides the interface to the RF feed network that incorporates a rotary joint (L-type) for each axis. The feed network is routed through the hollow shafts of the elevation and azimuth actuators.

A twist capsule serves as the rotary signal transfer and is located below the azimuth mechanism and the Spacecraft (SC). It provides the interface to the SC and serves as support for the Hold Down and Release Mechanism (HDRM) bracket.

Rapid prototype produced during development (Norway).

MSA Assembly in stowed position.

During 2013, 59 new technology activities were initiated under the frame of the GSTP addressing new needs and emerging applications.
MILLIMETER WAVE VALIDATION STANDARD (MM-VAST) ANTENNA

With the participation of Denmark

Inter-comparison and validation of antenna measurement ranges, either with readily available antennas or with dedicated VAST antennas, has been carried out for at least three decades. These activities allow finding and help correcting big and small problems in the measurement procedures, thus leading to an improvement of the measurement accuracy and facilitating better understanding of the measurement techniques.

The early experience gained demonstrated that readily available antennas can be useful, but do only partially meet the requirements of a validation campaign. Thus, it is definitely preferred to have available dedicated test or VAST antennas specifically designed for validation campaigns of antenna measurement ranges.

Today, there is a well identified need for increased operational frequencies to get access to large bandwidth and broadband communication. For several missions, user up/down link is performed at Ka-band while the use of Q/V bands is contemplated for the feeder links in the coming years. To support this frequency band move, VAST antennas at mm-wave frequencies should be made available to the community.

The main objective of this activity is to develop a well-characterised, mechanically and thermally stable multi-frequency reflector VAlidation STandard antenna for range qualification at mm-wave frequencies (mm-VAST).

MULTI-NEEDLE LANGMUIR PROBE (M-NLP) DEVELOPMENT

With the participation of Norway

The M-NLP is a new concept of a Langmuir probe system for high resolution measurements of space plasma density. It consists of two or more cylindrical needle probes. Depending on the plasma parameters in the specific low Earth orbit, the probes have typically a length of 25 mm and a diameter of 0.5 mm.

The instrument allows for high-resolution F-region plasma (electron) density measurements along the orbit trajectory (gradients, turbulence, irregularities). By this, the F-region plasma characteristics can be mapped around the globe.

In the frame of this activity a detailed design of a Multi-Needle Langmuir probe system for monitoring ionospheric electron density will be produced and an engineering qualification model (EQM) of the multi-needle Langmuir probe assembly (including sensors, boom and deployment mechanism, and auxiliary units) will be developed, manufactured, tested and qualified.

The boom assembly will be designed with a flexible interface that will allow the accommodation on various spacecraft with little or no modifications. Software for on-board data processing will also be designed, developed, verified and tested.
IRENE is a low-cost re-entry capsule, able to return payloads from the International Space Station to Earth and/or to perform short-duration, scientific missions in Low Earth Orbit (LEO).

The main features of the IRENE capsule are:

• a fixed nose (made by a special ceramic material).

• a deployable aero-brake (umbrella-like, made by special multi-layered fabric).

The MINI-IRENE activity aims to identify a low cost demonstration mission as a piggy-back payloads in a sub-orbital Maxus sounding rockets future mission. The configuration for the launch with the sounding rocket is characterized by smaller dimensions and lower cost.

The objective of the activity is the phase B design of MINI IRENE capsule, including structure, heatshield, deployment mechanism and electronic subsystems. Moreover this activity includes the development of a scaled technology “ground demonstrator” (a breadboard) of the variable geometry umbrella-like heatshield of IRENE capsule, the Mini-IRENE. The deployable system may be applied to any ESA mission in the frame of Science and Robotic Exploration Program, requiring planetary entry, as well to any ESA mission in the frame of Human Spaceflight, requiring planetary entry or re-entry.

The technology offers also an interesting potential for aerobreaking/aerocapture and for de-orbiting. It is also valuable in other fields than entry (deployable components).
Green Platform SCOE and Clever SAS Power Supply

Satellite test systems contain special power supplies, where the requirements are such that the highest priority customer goal, namely a silent working environment, could not be realized until now due to inherent low energy efficiency. Power supplies with high power dissipation aside from the energy cost have the disadvantage of lower reliability and of necessary extra equipment for cooling. Apart from the typical power supply use, this piece of equipment will be able to operate also as a Solar Array Simulator (SAS).

Motivation is to develop a novel, agile power supply component, which despite the diversity of requirements can cope with any usage scenario and leads to a generic, even reconfigurable standard product named "Green Platform SCOE". The system topology is very advanced and has very fast dynamics in order to comply with the SAS requirements.

Compared to previous solutions this system has the following advantages: less Power Dissipation and less noise, less volume, Bidirectional Operation, enhanced simulation capabilities and versatile usage scenarios including SAS, simplified cabling, increased reliability and substitution of a number of COTS items.

High Gain Data Downlink X-band Antenna

Data downlink transmission antennas for Earth Observation (EO) missions operation in Low Earth Orbit (LEO) are normally characterized by a pattern that is shaped in such a way that the power flux density is constant regardless of where the ground station is located within the coverage area (iso-flux pattern). The main challenge for the iso-flux antenna design is to meet the relatively high gain requirements at large polar angles while maintaining a good cross-polar discrimination and low gain variation within the coverage and over the frequency band.

The main objective of the proposed development is to design and pre-qualify a new X-band antenna for use in data downlink applications. The performance of the proposed antenna shall surpass the performance of current iso-flux coverage helix antennas for the X-band primarily by providing a higher Edge of Coverage (EOC) peak gain and also steeper gain slope outside the edge of coverage. By optimising a design based on a number of parameters (including: power handling, dimensions, mass and cost) it is expected to develop a very attractive and competitive product suitable for range of EO missions.
AO Activities Closed in 2013

K-BAND GROUND STATION LOW NOISE AMPLIFIER (LNA) DEVELOPMENT FOR EARTH OBSERVATION MISSIONS

Currently, Earth Observation (EO) satellites only use the X-band for the downlink between 7.75 and 7.9 GHz in meteorological satellites or between 8.025 and 8.4 GHz for other satellites. Unfortunately, these bands are not only limited in bandwidth, but they are also becoming too congested. Moving to the 26 GHz band, where the available bandwidth is four times higher than in the X-band, will represent a major leap in downlink capacity for the next generation of EO satellites in LEO orbits.

The low noise amplifier (LNA) is a key component in the Radio Frequency reception system of every satellite ground station. To fulfill the reception requirements for future EO satellite missions either existing ground stations will have to be modified to work in the new frequency band, or new ground stations will have to be built. Either way 26 GHz LNAs will be required.

The objectives were to develop two concepts of LNA for K band ground stations. It will be used for the reception of downlink payload telemetry from EO satellites:

- The first product was a compact cryogenic LNA for K band (25.5-27 GHz) ground stations which have significantly reduced noise temperature compared to uncooled LNA. In addition, highly efficient and long-life cryogenic coolers were used for this product, leading to extremely long Mean Time Between Failure (MTBF) performance.

- The second product was standard uncooled LNA for K band (25.5-27 GHz) ground stations. This product is developed using the same Microwave Monolithic Integrated Circuit (MMIC) as for the first product and so will benefit from a shared design and chip fabrication effort.

The products were designed, developed and tested with success.

DEVELOPMENT OF A PORTABLE, INTEGRATED POINT-OF-CARE DIAGNOSTIC PLATFORM FOR MULTIPLEXED ASSAYS

Human whole blood analysis in space, on board the ISS has several constraints that can alter the scientific outcome of an experiment, limit the analysis time which is needed to validate the results and complicates the on-board work order logistics. Real-time diagnosis of clinical samples in a quick, user-friendly and efficient way can offer new possibilities to extend the scope of the experiments, close the linkage between diagnostics and therapeutics, and minimise inaccuracies from sample degradation over time. Such technology could enable clinical laboratory-grade performance in a microgravity environment that has not been available.

The objective of this Study is to demonstrate the feasibility of a Point-of-Care (POC) platform to deliver an integrated candidate immunochemistry assay cost-effectively, from a finger-prick of whole blood, without the need for offline sample preparation. A goal of the Study was to use one of the most demanding immunochemistry assays, namely thyroid stimulating hormone (TSH), as a demonstration of the platforms performance, integrated sample preparation and usability.

In the frame of this activity, the feasibility of integrating TSH onto its POC blood analyser platform has been demonstrated, with assay performance set at the outset of the Study. Further development will result in integrating the whole system in a prototype to detect creatinine and Interleukin-6.

A K-band conventional LNA product.

A Example microfluidic disc.
→ WHEN SPACE GOES MICROSCOPIC

THE LOW MASS, HIGH INTEGRATION AND THE RELENTLESS SEARCH FOR NEW APPLICATION FIELDS MAKE MEMS (M I C R O E L E C T R O M E C H A N I C A L S Y S T E M S) AN INEVITABLE TECHNOLOGY FOR A SECTOR CRAVING HIGHLY EFFICIENT AND RELIABLE SYSTEMS. THE INCREASING NUMBER OF COMMERCIAL APPLICATIONS BASED ON MEMS DEVICES OPENS NEW OPPORTUNITIES FOR THE TRADITIONAL SOLUTIONS IN THE SPACE SECTOR. AS A MATTER, MEMS TECHNOLOGY IS NOW GRADUALLY BEING ACCEPTED FOR SPACE APPLICATIONS SOME EXAMPLES ARE: A MEMS GYRO BY SENTINEL 3, A MEMS PRESSURE SENSOR ON AEOLUS AND A MEMS FLOW SENSOR ON GAIA.

MINIATURIZATION OF A MAGNETOMETER BASED ON MICRO TECHNOLOGY

With the participation of Portugal

The overall objective of this activity is to prototype and extensively characterise a fully monolithic magnetometer based on MEMS technology. Being monolithic, will allow easier, faster and cheaper space qualification via the ESCC system. This activity will, among others, assess new concepts and MEMS technologies to miniaturize magnetic sensors into a smaller and fully monolithic device based on existing MEMS commercial.

MICRO POINT OF LOAD (POL) REGULATOR

With the participation of Belgium

Point Of Load (POL) Regulators supply power to low voltage high-performance semi-conductors such as Application-specific integrated circuit, Field Programmable Gate Array (FPGA) or mass memories.

The principal aim of the activity was to design, develop and qualify a European Point of Load (POL) converter. The initial work covered the specification of the device and a trade-off of design solutions. The envelope specification has been fixed to develop a non-isolating buck-type POL. A study of the power distribution architecture for low voltage systems was also made taking into account the management of failure modes.

Extensive breadboard testing has been performed, including verification of the behaviour in simulated failure modes, of a complete system of single Intermediate Bus Converter (IBC), 2 POLs supplied by the same intermediate 5V bus and output voltage clamp. Extensive analysis was also performed in support of the design. Subsequently the regulation and switching part of the POL design has been integrated into a flatpack hybrid. The hybrid can now be provided as a qualified product and is associated with a detail specification detailing all major characteristics and test limits, as well as a detailed user manual giving all information necessary for implementing the hybrid within its qualified limits, both electrical and environmental.
Driven by the requirements of astronomy (e.g., HERSCHEL HIFI and ALMA) and aeronomy instruments (e.g., EOS MLS, STEAM-R), sub-millimetre heterodyne radiometer technology has markedly improved in the last few years. Complete receiver assemblies remain costly to develop, cumbersome to assemble, and are at least partly limited in performance and reliability by their handcrafted construction and discrete component interconnects.

The micromachining methodology offers the potential realisation of a much larger truly two-dimensional array. Such an approach would greatly simplify manufacture and assembly.

Two drivers were identified for this technology: The first is imaging arrays and the second is related to the next generation of EUMETSAT Polar System which would include instruments going up to these frequencies. Based on both these drivers, the purpose of this study was twofold; firstly to design, manufacture and test an RF imaging array at 320 GHz and secondly to design, manufacture and test an integrated front-end for a sub-millimetre-wave radiometer working at 664 GHz.

In the frame of this activity, New design, fabrication and assembly techniques were developed to demonstrate the 340 GHz front-end receiver array and the critical 664 GHz front-end components. The measured performance of the 8-element 340 GHz array has demonstrated the feasibility of integrating Schottky mixers and same Microwave Monolithic Integrated Circuit (MMIC) LNAs into the same split-block, and the similarity in noise performance across the 8 elements proves that the assembly techniques employed are robust enough to provide repeatable performance for multi-element systems. The development of the 332 GHz doubler for the 664 GHz receiver demonstrated the feasibility of fabricating an integrated circuit on GaAs incorporating a 4-anode varactor diode chip. The demonstrated performance of the discrete diode 664 GHz mixer, is comparable with existing mixers.

The objective of this activity is to design, build and test a fully functional MEMS based gas chromatograph and mass spectrometer breadboard for a potential application for planetary missions, taking into account the latest developments in the field and making use of the most recent developments which are accessible.

The next steps will include the hardware procurement and the production of the first prototype GC columns based on MEMS technology. As a first step, a PVD process is foreseen to apply the stationary phase on the silicon wafer based column. Functional testing later this year will be followed by a system integration and test of the whole GC-MS system.

Gas Chromatography (GC) and Mass Spectrometry (MS) are standard tools for the analytical separation and identification of molecules, atoms and their isotopes. Recent progress in the area of MEMS devices have shown that the envelope and power consumption of Gas Chromatography and Mass Spectrometry can be significantly reduced without jeopardising performance characteristics to a major extent compared to laboratory bench top models. As mass and power are of vital importance for flight instruments, it is considered an area of high potential for MEMS based systems. Reduced mass and power requirements can lead to smaller payloads, enabling additional functionalities and redundancy, or even a smaller overall mission envelope, thus reducing cost.

The objective of this activity is to design, build and test a fully functional MEMS based gas chromatograph and mass spectrometer.
With the participation of Belgium, Luxemburg and Canada

Proba-V mission is an Earth Observation mission supplying worldwide vegetation data. The ‘V’ stands for Vegetation – a lighter redesign of the ‘Vegetation’ imaging instrument previously flown on France’s full-sized Spot-4 and Spot-5 satellites. This miniature satellite is designed to map land cover and vegetation growth across the entire globe every two days.

Launched on 7 May 2013, Proba-V has been designed to continue the supply of this imagery for applications such as climate impact assessments, water resource management, agricultural monitoring and food security estimates.

The Vegetation instrument

Proba-V has been specifically designed for global environmental and agricultural monitoring. It will extend the dataset of the long-established Vegetation instrument carried on the French Spot-4 and Spot-5 satellites, launched in 1998 and 2002 respectively.

The use of the data is not limited to just vegetation monitoring. Vital uses of the data include day-by-day tracking of extreme weather effects, alerting authorities to crop failures, monitoring inland water resources and tracing the steady spread of deserts and deforestation.

The new Vegetation instrument consists of three identical wide field of view pushbroom imaging spectrometers (each with a field of view of 34 degrees to cover the entire required swath). Despite its size, Proba-V has a continent-spanning 102° field of view with a 2250 km wide swath. This width of view means that Proba-V will provide global coverage every two days and cloud less global coverage every 10 days. Moreover, most of Earth’s landmasses will be imaged every day. The instrument relies on a set of high performance miniaturized Three-Mirror Anastigmat (TMA) based telescopes allowing the VEGETATION instrument to be an order of magnitude smaller than the SPOT version and yet providing higher resolution. With a ground resolution of 350 m on full field of view and 100 m resolution viewing at nadir, Proba-V will provide a clear picture of the plants so their health can be easily monitored.

Proba-V collects light in 4 spectral bands, the blue, red, near-infrared and mid-infrared wavebands. Thanks to these four spectral bands, Proba-V can distinguish between different types of land cover and plant species, including crops.

Vegetation instrument.
The Nile Delta in Egypt, acquired by Proba-V on 24 March 2014.

Refilling of Aral Sea. The Aral Sea, once two times the size of Belgium has been shrinking since the 1960’s. In 2007 the size has shrunk to an area half of Belgium. In 2009 the eastern part of the Great Aral Sea even dried out. Satellite photos now show that the eastern part is refilling again.

Central Asia’s receding Aral Sea, viewed by ESA’s Proba-V mini satellite, which is about to take up the continuing operational task of tracking global vegetation. Acquired on 13 May 2014, the 300 m-resolution Proba-V image depicts the white salt terrain left behind by the southern Aral Sea receding, now called the Aral Karakum Desert. The greenery to the south is cultivated land irrigated by the Amu Darya river.
Currently, the most important barrier to the evolution of control interfaces between on-board software and ground software is risk aversion. Most control software in space, or on the ground, is mission critical.

The OPS-SAT mission aims to change the current situation. The name “OPS-SAT” stands for Operations Satellite to highlight that its objective is to kick start innovation and break the “has never flown, will never fly” cycle in the satellite control area. It will consist of a satellite that will be only 30 cm high but that will contain an experimental computer that will be ten times more powerful than any current ESA spacecraft. Its goal is to accelerate innovation by providing operators with a reconfigurable flying laboratory where experiments and demonstrations can be done in a high performance and realistic but safe environment.

A major challenge in the project has been to design a spacecraft safe enough to allow these experiments while avoiding costly detailed ground checking before executing them. Therefore the satellite has to remain power positive and thermally safe in any attitude and to be resettable and recoverable by at least two independent communication channels. Also the use of commercial components means that the mission will experience significant noise effects. This has to be compensated for by appropriate fault detection hardware and software design. A specific highlight of OPS-SAT is the ability to run risky operation experiments on the payload module while enabling a reliable return to standard operations in case of failures or unexpected behaviour.

OPS-SAT Phase A/B1 was initiated in 2013 with the participation of Austria, Denmark and Germany and completed in Q1 2014.
During this phase a set of Mission and System requirements and associated System Design has been consolidated with the main goals of ensuring high performance allowing the accommodation of the maximum number of experiments and the safety and reliability of the whole system.

The implementation phase (Phase B3/C/D/E) will be initiated at the second half of 2014, introducing Poland to the consortium, with an estimated launch in 2016.

Major achievements of Phase A/B1:

- Incorporation of an array of the state of the art FPGA allowing the programming of software and firmware to be mixed in the same algorithm.
- Identification of a suitable CCSDS (Consultative Committee for Space Data Systems) S-band transponder that will provide 1 Mbps downlink and 256 kbps uplink.
- Identification of a camera with an improved ground resolution (below 80m).
- Modifications in the camera interfaces to allow video capture and enable various proposed experiments requiring super resolution.
- Incorporation of an advanced Attitude Determination and Control Subsystem board with an integrated all-in-one system with star tracker, reaction wheels and a full set of attitude control algorithms. This provides a pointing accuracy of << 1° compared to 10 degrees with the traditional cubesat systems.
- Approach to mitigating the effects of space radiation due to flying non space qualified electronics.
- Redundant units for some critical functions to improve spacecraft safety.

### PAYLOADS OF OPPORTUNITY

The Phase A/B1 study has identified the following potential payloads of opportunity as strong candidates:

**Software Defined Radio Frontend (Participation of DE)**

This very small unit consisting of a tuner, down-converter and A/D converter can be integrated and interfaced directly to the processing core. Complex signal samples can be delivered to the processor core, where signal processing can be performed. This allows the monitoring and demodulation of radio signals for a wide frequency range.

**Optical Receiver for uplink experiment (Participation of DE)**

This optical communications experiment will allow an optical uplink for the first time on a Cubesat with a transmission rate of several kbps using a small optical receiver which fits into OPS-SAT and consumes only 1 W of electrical power.

**X Band transmitter (Participation of FR)**

Flying this unit on OPS-SAT would produce synergies with many of the experiments as the mission return in terms of data download would be greatly increased. This is especially important for experiments that want to record video.

### No. of Experiments per country

<table>
<thead>
<tr>
<th>Country</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>22</td>
</tr>
<tr>
<td>Austria</td>
<td>11</td>
</tr>
<tr>
<td>ESA/ESOC</td>
<td>10</td>
</tr>
<tr>
<td>UK</td>
<td>10</td>
</tr>
<tr>
<td>Spain</td>
<td>10</td>
</tr>
<tr>
<td>Switzerland</td>
<td>6</td>
</tr>
<tr>
<td>France</td>
<td>6</td>
</tr>
<tr>
<td>Belgium</td>
<td>5</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2</td>
</tr>
<tr>
<td>Italy</td>
<td>1</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>1</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>1</td>
</tr>
<tr>
<td>Greece</td>
<td>1</td>
</tr>
<tr>
<td>Hungary</td>
<td>1</td>
</tr>
<tr>
<td>Slovenia</td>
<td>1</td>
</tr>
<tr>
<td>Ireland</td>
<td>1</td>
</tr>
<tr>
<td>Poland</td>
<td>1</td>
</tr>
<tr>
<td>Canada</td>
<td>1</td>
</tr>
<tr>
<td>USA</td>
<td>1</td>
</tr>
<tr>
<td>Egypt</td>
<td>1</td>
</tr>
</tbody>
</table>

▲ By the end of 2013, over 100 companies and institutions from 17 European countries registered experimental proposals to fly on OPS-SAT. 91% of the experiments proposed can be accommodated with the new design.
The past year 2013 has seen a continuation of the GSTP achievements in technology developments. Selected accomplishments are illustrated in this GSTP Annual Report 2013. Overall, in 2013, the GSTP supported a remarkable number of new technology developments, representing 59 new activities (worth around 35 M€) and 41 closed activities (worth around 23 M€).
K-Band Ground Station Low Noise Amplifier (LNA) Development for Earth Observation Missions

→ Spectroscopic Terahertz Imaging Radar (STIR)

→ Mechanically Steerable Data Downlink Antenna
→ High Gain Data Downlink X-band Antenna

→ Millimeter wave Validation Standard (MM-VAST) antenna

→ Advanced Slip-Ring Solutions
→ Cryostat Technology development for Electrodynamic Heat Shield
→ Biochemical Analyzer Technology (BIOCAT)
→ Pressurized Housing Development for Space Lasers
→ 16-bit ADC

→ Micro Point of Load (POL) Regulator
→ Proba-V

→ MEMS based Gas Chromatograph/Mass Spectrometer.

→ Advanced Slip-Ring Solutions
→ Green Platform SCOE and Clever SAS Power Supply

→ Maxus International Nacelle to investigate IRENE capabilities (Mini IRENE)

→ 16-bit ADC
ANNEX 1

LIST OF DOCUMENTS TO THE INDUSTRIAL POLICY COMMITTEE

IPC 277 - Paris - 29th and 30th of January 2013
ESA/IPC(2013)4 Update of the GSTTP-4 Work Plan/Procurement Plan
ESA/IPC(2013)5 Update of the GSTP-5 Element 1 Work Plan/Procurement Plan

IPC 278 - Paris - 9th of April 2013
ESA/IPC(2013)27 GSTP-6 Element 1 Work Plan/Procurement Plan
ESA/IPC(2013)52 Update of the GSTP-5 Element 2 Work Plan/Procurement Plan
ESA/IPC(2013)54 Update of the GSTP-5 Element 4 Work Plan/Procurement Plan
ESA/IPC(2013)5, add.1 Update of the GSTP-5 Element 1 Work Plan/Procurement Plan
ESA/IPC(2013)71 General Support Technology Programme (GSTP) Period 5 Element 3 Status Report
ESA/IPC(2013)5, add.2 Update of the GSTP-5 Element 1 Work Plan/Procurement Plan

IPC 280 - Paris - 15th of May 2013
ESA/IPC(2013)72, rev.1 GSTP: Request for transfers of contributions by Austria, the Czech Republic, Denmark, Finland, Ireland, Italy, Portugal, Switzerland and the United Kingdom
ESA/IPC(2013)5, add.2 Update of the GSTP-5 Element 1 Work Plan/Procurement Plan
ESA/IPC(2013)4, add.1 Update of the GSTP-4 Work Plan/Procurement Plan
ESA/IPC(2013)32, add.1 Update of the GSTP-5 Element 2 Work Plan/Procurement Plan
ESA/IPC(2013)61, add.1 Update of the GSTP-6 Element 1 Work Plan/Procurement Plan
ESA/IPC(2013)77 Procurement Plan for activities planned for 2013 Part 2 and Part 3 European GNSS Evolution Programme

IPC 281 - Paris - 26th and 27th of June 2013
ESA/IPC(2013)61, add.2 Update of the GSTP-6 Element 1 Work Plan/Procurement Plan
ESA/IPC(2013)78 GSTP-6 Element 1 Work Plan/Procurement Plan Specific Area Work Plan for Clean Space
ESA/IPC(2013)63 GSTP-6 Element 3 Work Plan/Procurement Plan
ESA/IPC(2013)5, add.1 Update of the GSTP-5 Element 1 Work Plan/Procurement Plan
ESA/IPC(2013)61, add.3 Update of the GSTP-6 Element 1 Work Plan/Procurement Plan
ESA/IPC(2013)4, add.2 Update of the GSTP-4 Work Plan/Procurement Plan

IPC 282 - Paris - 24th and 25th of September 2013
ESA/IPC(2013)62 GSTP-6 Element 2 “Competitiveness” Procurement Plan
ESA/IPC(2013)78, add.1 Update of the GSTP-6 Element 1 Work Plan/Procurement Plan Specific Area Work Plan for Clean Space
ESA/IPC(2013)61, add.3 Update of the GSTP-6 Element 1 Work Plan/Procurement Plan
ESA/IPC(2013)5, add.4 Update of the GSTP-5 Element 1 Work Plan/Procurement Plan
ESA/IPC(2013)112 GSTP: Request for transfers of contributions by Austria, Canada, Switzerland, Ireland and the Czech Republic
ESA/IPC(2013)99 Draft Programme Security Instructions (PSI) for the General Support Technology Programme (GSTP) and draft amendment of GSTP Implementing Rules

IPC 283 - Paris - 19th and 20th of November 2013
ESA/IPC(2013)5, add.5 Update of the GSTP-5 Element 1 Work Plan/Procurement Plan
ESA/AF(2013)84 Draft Revised Implementing Rules of the General Support Technology Programme (GSTP)
ESA/IPC(2013)61, add.4 Update of the GSTP-6 Element 1 Work Plan/Procurement Plan
ESA/IPC(2013)62, add.1 GSTP-6 Element 2 “Competitiveness” Procurement Plan
ESA/C(2013)74 Declaration of the General Support Technology Programme (GSTP)
ANNEX 2
GSTP BUDGET DISTRIBUTION BY THEMES (2004 -2013)

1- Earth Observation 15.86%
2- Science & Robotic Exploration 2.78%
3- Human Spaceflight 6.55%
4- Space Transportation & Re-entry Technologies 11.24%
6- Navigation 1.17%
7- Generic Technologies 59.24%
8- SSA 0.09%
9- Robotic Exploration 2.24%
Pilot Projects 0.03%

ANNEX 3
COMPLETE LIST OF GSTP ACTIVITIES INITIATED IN 2013

<table>
<thead>
<tr>
<th>Prog. reference</th>
<th>Activity title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO06-21MS</td>
<td>Composite Space Structures Modelling and Analysis Software</td>
</tr>
<tr>
<td>AO06-29EE</td>
<td>High Gain Data Downlink X-band Antenna</td>
</tr>
<tr>
<td>AO06-30SW</td>
<td>Multicore in Integrated Modular Avionics</td>
</tr>
<tr>
<td>AO06-31EP</td>
<td>Green Platform SCOE and Clever SAS Power Supply</td>
</tr>
<tr>
<td>AO06-33MM</td>
<td>Development of an Ultra High Sensor Count Optical Interrogator Array</td>
</tr>
<tr>
<td>AO07-03MP</td>
<td>Qualification of a Micro PPT (PPTCUP) for Cubesat Application</td>
</tr>
<tr>
<td>AO07-04EE</td>
<td>HVLB Flexible Antenna Sprayhood</td>
</tr>
<tr>
<td>G101-29MS</td>
<td>Pressurized Housing Development for Space Lasers</td>
</tr>
<tr>
<td>G406-02MS</td>
<td>Maxus International Nacelle to Investigate IRENE Capabilities (MINI IRENE)</td>
</tr>
<tr>
<td>G511-019GI</td>
<td>Parallel Computing for Fast TM Processing During Short Passes</td>
</tr>
<tr>
<td>G511-042SY</td>
<td>Implementation of a Linear Variable Filter based Hyperspectral Focal Plane for Earth Observation Instruments</td>
</tr>
<tr>
<td>G511-045GR</td>
<td>Multiple Frequency Radar Compact Transponder (MUTE)</td>
</tr>
<tr>
<td>G513-009MM</td>
<td>MEMS based Gas Chromatograph/Mass Spectrometer</td>
</tr>
<tr>
<td>G513-039MC</td>
<td>Additional Unit for Increased Water Loop Closure</td>
</tr>
</tbody>
</table>
G513-041MC Melissa Pilot Plant
G513-058MM ANITA2 for International Space Station
G514-011MP Aerodynamics of Decelerators: Parachutes and Ballutes
G514-021MP Feasibility study for a Skylon based European Launch Service Provider (S-ELSO)
G516-005NA EGNOS V3 Phase B2
G516-006NA EGNOS V3 Phase B2
G517-004SY Space-Based Automatic Identification System
G517-036SW Establishment of a Simulation Model Reference Library
G517-058MM ANITA2 for International Space Station
G517-061MP Aerodynamics of Decelerators: Parachutes and Ballutes
G517-085SW Dynamic Translation based On-Board Processor Emulator
G517-099STu National Technology Transfer Initiative (NTTI) - Germany
G517-099STv National Technology Transfer Initiative (NTTI) - Belgium 2013
G517-117QT Tailor-designed carbon nanotubes for superior composites
G517-120SGab Wireless Sensor Technology / Energy Harvesting (WireTech)
G517-120SGaC SYN2 High-Power Li-ion batteries for satellites
G517-128QT GaN: Development of GaN H-FET onSiC Epitaxy for RF Application
G517-130GI SW Platform for Monitoring of ESA Mission Control Infrastructure
G517-131ET AGGA-4 Navigation Framework (A4NAF)
G517-134MS Identification of Structureual Interface damping Characteristics at Microvibration Loads
G517-136EE Multi-Needle Langmuir Probe (M-NLP) Development
G517-139EC Second Generation APS STR: Breadboard Step 2: Optical Head
G517-145SY Global Concurrent Engineering Infrastructure for Space Projects Lifecycle
G521-003ED Reconfiguration Module for Multimission Core Computer
G522-008SW On-board Software Reference Architecture for Payloads
G522-009SW Basic CoCs Software Validation (Part II)
G523-001EE Mechanically Steerable Data Downlink Antenna
G524-002ET Digital Sun Sensor on a Chip EQM phase 1
G525-004SW Software Elements for Security: Partition Communication Controller
G531-005ET Space Link Security- Cryptographic Processor
G531-009SY Next generation PROBA satellites Definition and Application
G547-009SY Cubesat Technology Pre-Development, QB-50.
G547-010OSa OPS-SAT Phase A/B1 (two parallel contracts)
G601-19MC Composite flow Moulding Components for Spacecraft Applications
G605-40MC Active Payload Adapter
G601-19MC Composite flow Moulding Components for Spacecraft Applications
G617-001MP Hall Effect Thruster (HET) Electric Propulsion (EP) subsystem for small satellites
G617-134MP Synergetic Air-Breathing Rocket Engine (SABRE) Development-Phase3A
G617-142ED 16-bit ADC

* Activities highlighted have articles in this document
# ANNEX 4

## COMPLETE LIST OF GSTP ACTIVITIES CLOSED IN 2013

<table>
<thead>
<tr>
<th>Prog. reference</th>
<th>Activity title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO06-03EE</td>
<td>Operational K-distribution based ship detection system using complex radar backscatter</td>
</tr>
<tr>
<td>AO06-04NA</td>
<td>Harbour Environment Pseudolites</td>
</tr>
<tr>
<td>AO06-13GS</td>
<td>K Band Ground Station LNA Development for EO Missions</td>
</tr>
<tr>
<td>AO06-14GI</td>
<td>SCDS-2000 migration to EUD</td>
</tr>
<tr>
<td>AO06-15SE</td>
<td>Earth Observation based 2D Structural Parameters for 3D Virtual Landscape Reconstructions</td>
</tr>
<tr>
<td>AO06-16SW</td>
<td>Generic Spacecraft Interfaces</td>
</tr>
<tr>
<td>AO06-18MM</td>
<td>Development of a portable, integrated Point-of-Care Diagnostic Platform for Multiplexed Assays</td>
</tr>
<tr>
<td>AO06-20EE</td>
<td>UHF Antenna for Environmental Satellites of opportunity for market-oriented activities</td>
</tr>
<tr>
<td>AO07-01EE</td>
<td>Georeferenced Airport Obstruction</td>
</tr>
<tr>
<td>AO07-05EP</td>
<td>Micro Buck Regulator</td>
</tr>
<tr>
<td>A06204</td>
<td>SMAAD Semantic-Web for Mediated Access Across Domains</td>
</tr>
<tr>
<td>AO86-01MM</td>
<td>Development of X-Ray Window Membrane</td>
</tr>
<tr>
<td>AO86-05SY</td>
<td>On Board Mission Scheduler</td>
</tr>
<tr>
<td>C51-MPC-853</td>
<td>Industrialisation of Advanced Composite Propellants</td>
</tr>
<tr>
<td>GI02-46EE</td>
<td>Micromachined Receiver</td>
</tr>
<tr>
<td>G103-13MM</td>
<td>Adaptation of Industrial Motor Technologies For Space Applications</td>
</tr>
<tr>
<td>G303-10MC</td>
<td>MELISSA: R.Rubrum Harvesting Techniques</td>
</tr>
<tr>
<td>G303-12MC</td>
<td>Waste Collector Unit</td>
</tr>
<tr>
<td>G308-11MM</td>
<td>Opening of a furnace and its repair</td>
</tr>
<tr>
<td>G401-01MZ</td>
<td>Cryostat Technology development for Electrodynamic Heat Shield</td>
</tr>
<tr>
<td>G410-04MM</td>
<td>High Speed Tunable Laser Interrogator for Spacecraft Health Monitoring</td>
</tr>
<tr>
<td>G51-02MM</td>
<td>Integrated MEOS LiNbO3 Mach-Zehnder interferometer for spectrometry in the 0.5 to 5 micron spectral region</td>
</tr>
<tr>
<td>G512-003EC</td>
<td>Precise Gravitational Modelling of Planetary Moons and NEO Asteroids</td>
</tr>
<tr>
<td>G512-004EE</td>
<td>QCL Local Oscillator Development</td>
</tr>
<tr>
<td>G513-006MM</td>
<td>Biochemical Analyser Technology (BIOCAT)</td>
</tr>
<tr>
<td>G513-004MM</td>
<td>Bone and Muscle Modelling</td>
</tr>
<tr>
<td>G517-024SW</td>
<td>Authoring environment for interactive 3D procedures</td>
</tr>
<tr>
<td>G517-122GS</td>
<td>Lunar Optical Communication Link (LOCL) Demonstration</td>
</tr>
<tr>
<td>G517-133SY</td>
<td>Open Concurrent Design Tool (OCDT) Enhancements</td>
</tr>
<tr>
<td>G522-002SW</td>
<td>On-Board software reference architecture consolidation (two parallel contracts)</td>
</tr>
<tr>
<td>G533-016EC</td>
<td>Orbit Propagation Algorithm for the Space Situation Awareness</td>
</tr>
<tr>
<td>G547-012SY</td>
<td>Space-based Automatic Identification System for Columbus: experimentation of new receiver configurations-CCN1</td>
</tr>
<tr>
<td>G601-18MC</td>
<td>Advanced RTM-Process for Manufacturing of CFRP Space Structures</td>
</tr>
<tr>
<td>G601-53ES</td>
<td>Essential Telemetry Support ASIC</td>
</tr>
<tr>
<td>G601-62MC</td>
<td>Carbon Fibre/Aluminium Sandwich Panels Interconnection System</td>
</tr>
<tr>
<td>G603-48EC</td>
<td>Extension of Sun Sensor Qualification Range</td>
</tr>
<tr>
<td>G605-04EM</td>
<td>ECSE Architecture</td>
</tr>
<tr>
<td>G607-20SW</td>
<td>Open Image Generation System II</td>
</tr>
<tr>
<td>G608-09QC</td>
<td>CTTB In-Flight Component Irradiation Test Data Analysis</td>
</tr>
<tr>
<td>G608-29QM</td>
<td>Feasibility Study on the Development of CoBlast Enabled White Thermo-Optical Surfaces</td>
</tr>
<tr>
<td>G608-31QT</td>
<td>Non-conventional Carbon Nanotube Skeleton Reinforced Composites Follow-on (NACo2)</td>
</tr>
<tr>
<td>G609-17MM</td>
<td>Target Projector for Videogrammetry (TPV)</td>
</tr>
<tr>
<td>G609-21MM</td>
<td>Advanced Slip-Ring Solutions</td>
</tr>
<tr>
<td>NP20-04SW</td>
<td>Integrated Modular Avionics for Space</td>
</tr>
<tr>
<td>G609-68EE</td>
<td>Spectroscopic Terahertz Imaging Radar (STIR)</td>
</tr>
<tr>
<td>PV-03</td>
<td>PROBA-V</td>
</tr>
</tbody>
</table>

*Activities highlighted have articles in this document*
GSTP Participating States

Austria
Belgium
Czech Republic
Denmark
Finland
France
Germany
Greece
Ireland
Italy
Luxembourg
Netherlands
Norway
Poland
Portugal
Romania
Spain
Sweden
Switzerland
United Kingdom
Canada