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| Ångström Space Technology Centre, Dept. of Eng. Sci., Uppsala University | Greger Thornell | Microelectromechanical systems for space | With respect to functionality and performance, Microelectromechanical systems, MEMS, technology is beneficial for most aspects of space technology, but is particularly competitive where:<br>- sensitivity and resolution is of interest (e.g., high-performing scientific instruments, but also, e.g., small-impulse propulsion systems), and<br>- when small, but highly functional, spacecraft (e.g., formation flying, fractionated spacecraft for large virtual aperture measurements) are employed.<br><br>Specific research, relating to (micro-) device level, should address:<br>- reliability and quality aspects in general, redundancy and other means to compensate for insuffiecient quality,<br>- space environmental issues (susceptibility to radiation damages, thermal fluctuations, shock, vibrations, ...),<br>- multifunctionality and integration aspects to maximize miniaturization benefits with respect to size and mass,<br>- scale effects (advantages and disadvantages with reduced size, and use of new, small-size-specific effects/phenomena)<br><br>The first two are necessitated by space industry's conservatism, which is alleviated by rigorous testing and qualification. The last two are to further pave for development of space technology in space. | Europe has, but risks to loose, scientific and technical advantage in the so far small intersection of MEMS and space technology mostly because of its scattered academic efforts. This intersection has, *per se*, an enormous economical growth potential. The development of the two fields by themselves, reported in monetary terms, is indeed indicative, and the technical benefits of employing MEMS in space applications have been pointed out by researchers worldwide. Adding to this, are the terrestrial spin-offs of space technology, which usually are claimed to be about 6-7 times bigger than the primary investment driver. Both fields are of course highly technological and hence corresponding well with Europe's educational trends, and the occupation of its engineers and scientists *to*, *of* and *beyond* 2020. |
| AREVA | Jean-Pierre Roux | Space nuclear reactors: a necessary breakthrough for space exploration (as it has been for submarines) in term of propulsion and surface power generation. | Space Nuclear Power Systems are unanimously recognized to be compulsory for solar system exploration, at least for deep space missions or planet surface exploration. The first step in SNPS is the radioisotopic generator, so called RTGs, currently under development in the frame of ESA's programmes.The necessary step beyond is nuclear reactors for large scale Mars missions and beyond, delivering higher power from 10s of kW up to megawatts of electrical power. Reactors are well known on Earth for electricity generation on ground and on/under the seas for propulsion. In space, the lack of atmosphere or water for cooling leads to implement very large radiators. To limit the radiating area requires high temperature fast reactors and coupling with highly efficient thermo- electric conversion system.So space reactors are a great technological challenge:- in nuclear technologies, where high temperature fuels are required, as well efficient primary cooling,- in conversion technologies, where efficient thermodynamic cycle is sought, as well as electrical generation,- at system level, where the mass, volume, reliability of the system are critical as for all space systems, - at safety level, considering the operational phases at ground and the mastering of nominal and failure phases from launch up to end of the mission Currently, studies are carried out at national level to identify the best solutions to afford to these reactors. Then a technological road-map will be drawn up and FP8 will be an opportunity to progress on these technologies. The topics that need to be addressed are notably those herabove mentioned to be completed by:- system preliminary design, sizing and modelling, - experimental assessment of the structure materials, fuel, reactivity control, heat transportation loop, conversion loop, radiator and radiological protection, and all other qualification activities necessary before aiming a ground prototype. | Space Nuclear Power Systems are internationally recognized to be compulsory for solar system exploration, at least for deep space missions or planet surface exploration. A working group led by EC DG RTD wrote a report in 2005 stated that "nuclear power sources are essential and enabling key assets for a significant number of space exploration missions". The group recommended a reduced dependence for short and medium term towards an increased dependence in the long term. Radio-isotopic sources are considered in the medium term, while reactors in the longer term. ?? Where are we in 2010 ? Recommendations have been followed regarding radio-isotopic sources, which are currently under development through ESA programme. Reactors and propulsion are not yet addressed. A programme for space nuclear propulsion is a great technological challenge that should be a structuring programme for European nuclear, space and scientific community, certainly inspiring young European engineers and scientists. It should be a driver for innovation with potential spin-off in energy field. It should be an input for future international collaboration relating to manned solar system exploration. Mastering of such concepts will clearly open the door for a decisive European contribution to any future space exploration mission. |
| ARQUIMEA Ingeniería S.L. | Francisco Gutiérrez | Use of Shape Memory Alloy materials in space applications: Actuators and SMART structures | Shape Memory Alloy materials present special properties with advantages when properly used in certain applications that require precision and reliability. Last developments in the manufacturing process make possible the production of these materials to be used in extended temperature range and with a reasonable manufacturing cost.<br><br>With and adequate mechanical design, these materials can be used in different applications, from different types of actuators to trigger mobile mechanisms to active springs or intelligent structures.<br><br>Although some of these applications are already been investigated by ESA, mainly using SMAs in the form of a fiber, additional research are necessary to optimise the materials and the associated mechanical designs to extend the areas of applications in the satellite field.<br><br>The proposal is to analyse the potential application of these SMART MATERIALS in space and to develop new material manufacturing processes to allow its use in these applications. Also a formal material qualification for space has to be developed. | The development of space application Shape Memory Alloy (SMA) SMART MATERIALS in Europe will have an important impact in the development of space mechanism in Europe since it will allow the replacement of the current technologies used as triggering mechanisms by more reliable ones supporting the European non-dependence in space technologies.<br>The impact of the development of this technology is not limited to space. The development of the proposed technology for space will directly open the door to transfer these technologies to other areas such as medicine (artificial muscles and valves), automotive (replacing several electrical motorised actuators and valves) and Aeronautics (replacement of electrical motors and generation of smart structures). All these elements together may represent and important industrial development with the corresponding increases of competition of the European industries and creation of employment. |

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| Astos Solutions GmbH | Andreas Wiegand | Investigation of Active Debris Removal strategies of small and large objects in strategic important orbits | Active Debris Removal requires research in a broad field:<br>- Strategies to clean an orbit from small debris, e.g. Iridium/Cosmos collision at different orbit<br>- Strategies to remove larger objects with manipulators (dead satellites, upper stages, solar panels ...)<br>- Best strategies to encounter debris all classes of debris in general or to transform it between such classes for better mitigation.<br>- Technology for in-orbit debris detection required for in-orbit debris servicing<br>- Cross link to ongoing research for debris mitigation by shielding<br>A major result should be at least the full awareness of the mitigation capabilities and to determine required technologies with their TRL. Most promising technologies should be further developed. | The risk of damaging the utilization of important orbits is growing continuously. A collision or other debris source in GEO would have dramatic consequences on the space environment and the technical services depending on that resource. The need for active debris removal is growing and it will become reality. First activities in the frame of in-orbit servicing are already on-going.<br>The capability to perform such service will give access to an important future market for space services with impact on jobs and also with potential for inspiration. |
| Astrium | Matthew Stuttard | Towards an operational system for advance warning of space weather conditions posing a hazard to critical European infrastructure (e.g. telecoms, power). | The research would develop technologies and concepts enabling a minimum cost approach to operational monitoring of solar storms.<br><br>Any eventual system must be designed to give the maximum possible warning of coronal mass ejections bound for Earth in order to allow preventative measures (e.g. power down etc.) to be taken. The research would build on knowledge gained from existing science missions such as STEREO, but would be focused on developing methods tailored to minimum cost operations.<br><br>This would involve research improving monitoring and modelling of solar activity to develop better predictive models of when CMEs CMEs on trajectories impacting the Earth's magnetosphere are likely to be produced as well as research developing efficient and robust techniques and system concepts for monitoring ejection events. | Space weather is a phenomenon with trans-boundary impacts which is currently monitored at a national or international level only through loose collaborations between science communities. Solar activity varies on an 11 year cycle and will be at maxima in 2012 and 2023. Past events have already shown that power and communications networks (as well as other infrastructure) are susceptible to avoidable damage caused by induced currents and generated by solar storms interacting with the Earth's magnetosphere. The European population is increasingly dependent on power and communications networks and is therefore increasingly vulnerable to serious consequences from electromagnetic pulse events. Mitigation action for solar storms is a subject which is fully relevant to the topic of Space Situational Awareness. As SSA is one of the pillars of European Competence in space under the Lisbon Treaty, it is essential that the EC FP8 programme embarks on research into operational mitigation of adverse space weather impacts. |
| Biology Department, Cell Biology | PD. Michael Lebert, Prof. Ralf Anken, PD. Ruth Hemmersbach , Prof. R. Hilbig | Gravitational Biology 2020: Study biology in space for life on Earth - from molecules to organisms | In the context of the last ESF evaluation of the ELIPS 3 program (2008) also European biologists met and identified three key questions to be addressed in the mid-term future (Scientific Evaluation and Future Priorities of ESA's ELIPS Programme).<br>To address these questions the following issues should be addresses in the context of FP8<br>- Close collaborations between small groups of laboratories selected on the basis of scientific excellence should be funded.<br>- Funding should also include funding of ground research.<br>- Development of highly modular experimental systems which work autonomously, analyse samples to maximal amount possible on board and could be extended in response to technological progress. This will address the limited up- and download capabilities.<br>- Space flight as well as ground based opportunities should be funded which allow for experiments with different weightlessness times from seconds to months: drop tower, parabolic flight, TEXUS, MAXUS, FOTON, BION. The use of the ISS platform is for many of these experiments not suitable or in some cases not required. | Key questions regarding the effects of gravity on organisms are:<br>1. How do cells sense, react and adapt to gravity and exposure to radiation? Both questions are crucial for any exploration over extended periods of time.<br>2. How do cells interact on all levels with their environment?<br>3. How is gravity shaping organisms (plants and animals)?<br>Due to our access to space conditions we are now in the position to address and answer the questions regarding the effects of gravity on molecules, cells, tissues and organisms. The unique environment in space also requires not only a strong knowledge and sometimes a reconsideration of the biology, but in addition, a strong sense for technology. Due to our experience people of all ages are very much attracted by these challenges. Young scientists working in this field get a most complete education and are very attractive for hiring by industries. Clearly, these are questions of basic research. However, the strong influence of technology always guaranties the awareness and willingness to search for possible applications. Therapeutical challenges with respect to understanding of malfunctioning of cells, such as those of the immune system, will be a further impact which justifies this kind of research. |

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| CASA* and Institute of Physics, University of Szczecin | Ewa Szuszkiewicz | Detecting and characterizing habitable exoplanets. | Theoretical work: orbital dynamics, stability, mean-motion resonances, planet formation,<br>gas giant – terrestrial planet coexistence, habitable zone, theory of planetary atmospheres<br><br>Observational methods: astrometry, transits, radial velocities, microlensing, single aperture imaging, multiple aperture imaging.<br><br>Example of specific research: climate changes on Mars and Earth – comparative studies. | The research topic proposed here is a strong inspiration not only for young Europeans but for the whole civilisation. It is truly interdisciplinary, going into direction of science integration which is essential for solving fundamental problems. It deals with our environment here on Earth, in the interplanetary space and in the extrasolar planetary systems. It stimulates technology development and practical applications. New attractive job opportunities will be available. |
| Central Research Institute for Machine Building (TsNIIMash), Roscosmos | Gennady Raykunov | a) Space Science and Microgravity, b) Enabling technologies for human exploration, c) Space foundation technologies,, d) Global space issues. | Space Science and Microgravity<br>Feasibility studies for space research missions, including Roentgen Microphone project for black holes' and other distant compact objects' research and Solar Probe for Solar corona research.Joint microgravity material science and life science research using Roscosmos' Vozvrat-MKA reusable space platform.Earth observation especially oriented towards hydrocarbonats' exploration methodology research.<br><br>Enabling technologies for human exploration<br>Research in large space deployable structures and habitable volumes.Research in crew radiation protection for interplanetary missions.Space robotics, including regenerative and self-servicing systems.Advanced control systems.Ground testing of the planet landers and Earth return vehicles, including aerodynamics, thermal protection, loading, etc.<br><br>Space Foundation Technologies<br>Research in joint design, manufacturing and supply integration of space EEE components.Technologies of unified spacecraft bus, including small size satellite platforms.Space cryogenics.Space propulsion and reusable launchers.<br><br>Space Debris Monitoring and Spacecraft Protection<br>Near Earth Objects' Hazards Mitigation and Space Segment Analysis | Suggested themes cover space missions' goals and enabling technologies. We are now prepared for more integrated approach to space research and technology development. Space Foundation themes allow more competitiveness for European industry joining competencies with Russian space enterprises and building common solutions and markets for space-rated components and technologies. Enabling Technologies for Human Exploration themes provide better understanding of needed full-scale efforts for future missions whose planning is going to start in the next decade. Space Science Research themes are those both actual from the standpoint of the current astrophysics and planetary science state-of-the-art and enjoying the significant background gained by Russian and European institutions, including but not limited to TsNIIMash, Lavochkin Association, Vernadsky Institute, Space Research Institute, Moscow State University, Institute of Astronomy, UK Lunar Penetrator Consortium, Max Planck Institute. These themes allow better understanding of the Universe' most exotic objects as well as most important object for the humankind, the Sun. Space debris and Near-Earth objects are among the critical issues the international space community will have to address in the 2020 timeframe. Joint research allows better understanding of the underlying phenomena and increasing the European industry and academia preparedness for the actual mitigation and protection measures. |

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| Centre Suisse d'Electronique et de Microtechnique SA, Switzerland | Steve Lecomte | Space-worthy optical frequency comb: a unique tool for multipurpose cutting-edge applications in space | The optical frequency comb (typically a stabilized mode-locked femtosecond laser) is a new and unique tool opening totally new capabilities and precision levels in many relevant future missions where metrology is pushed beyond current limitations. Among the possible applications, the optical frequency comb will be essential in instruments like optical atomic clocks, ultra-low phase noise microwave generation, optical communication, time and frequency transfer, spectroscopy, and distance measurement. The respective applications are tests of fundamental physics laws like general relativity thanks to ultra-stable and accurate future optical atomic clock and distance metrology for formation flying (missions like LISA where the objective is the detection of gravitational waves). Moreover the unique capabilities of the optical frequency comb to generate ultra-low phase noise microwave for synchronisation purposes, to allow new schemes for optical communication and time and frequency transfer between satellites and from ground to space, and even to allow new schemes for spectroscopy for planetary missions or Earth observation missions make it a very exciting "enabler". The current maturity of such laser systems is rather low regarding the compatibility of the commercial products for space applications. Current commercial products are either based on complicated and inefficient titanium-sapphire laser or radiation sensitive fiber laser technology. Those technologies are not, at the current stage, suitable for space application. ESA is interested in the optical frequency comb and identified possible missions requiring such a device but ESA also mentioned the lack of technology readiness level (TRL) for mission planning. That is the reason why the optical frequency comb is even mentioned in the 2009 European Space Technology Master Plan (ESTMP) as a critical component to be developed (Harmonised European Technology Roadmaps: Formation flying – Optical Metrology, activity reference D04). The objectives of this proposed activity are to investigate alternative technologies (for instance solid-state lasers and microtoroid optical resonators) and to push the maturity of commercial products (in particular the fiber laser technology) to identify and realize a spacecompatible optical frequency comb. Increasing the TRL of the optical frequency comb will allow ESA to plan cutting-edge missions requiring such a laser as well as supporting the effort started in the frame of FP7 space call for the development of optical atomic clocks. | The invention of the optical frequency comb already deserves Europe with the 2005 Physics Nobel Prize partially awarded to Prof. T. Hänsch from the Max-Planck-Institut für Quantenoptik, Garching and the Ludwig-Maximilians-Universität, Munich. This invention triggered and will continue to trigger people creativity. Already many schemes have been invented or demonstrated how to improve how measurements can be done compared to standard approaches typically with continuous-wave lasers. There is no sign that this creativity for new concepts will end soon and the optical frequency comb will be at the heart of future inventions. In the context of space science and technology, the optical frequency comb will be a unique enabler capable of massive improvements of the accuracy and precision of cutting-edge experiments or technologies. Scientists will be able to design and realize unique experiments in space to further test and investigate the most intimate laws of physics or improve Earth observation. The optical frequency comb is therefore a unique device with great potential for Europe to foster its laser manufacturing industry as well as its space industry. The optical frequency comb will also contribute to maintain the European leadership in strategic technologies related to metrology, telecommunication, and navigation. |
| CEON GmbH | Volker Schumacher | Connecting the user needs and requirements at regional-level to the European-level services derived from space based technologies (GMES, Galileo) by various measures (i.e. dissemination transfer centers, semantic tools) to promote economic growth | The research to be carried out shall be based on previous achievements made so far in this area (FP7, GMES, Galileo applications development) and shall be implemented for instance via a European network of regional nodes that can act as transfer and dissemination centres and facilitators. The research to be performed should address at least the following levels in order to cover the crucial aspects where barriers to market expansion still prevail:Addressing/ removing language barriersTo overcome one of the major barriers faced by regional stakeholders who are not always familiar with the English language, a prime requisite is to develop and promote the use of language independent tools and technologies in combination to geographical visualisation approaches (i.e. semantic services, web mapping) to boost the access to relevant information tailored to the specific needs of the user community.Performing targeted demonstrations with dedicated user involvementIn order to be successful, space based services and their benefits shall be demonstrated in specific support actions ("regional demonstration test beds") and a structured access to these services must be established for regional users ("network of certified dissemination and transfer centers"). This will not only enable potential users to identify solutions appropriate for their specific needs, but also help to overcome the lack of staff resources often faced by public authoritiesDefining and implementing a governance model at regional levelFacilitating the uptake and connection to the European GMES Service segment at regional level by using a bottom-up approach requires a governance structure suitable to both regionaland compatible with European governance. This implies also the definition of long-term funding models. | European Regions represent a big reservoir of new potential GMES users provided they can be convinced that GMES services add value to their existing services. However, the success of reaching the stakeholders in the European regions with respect to operational and sustainable GMES downstream services depends on the capacity to reach these potential users and to connect them with the suitable providers across Europe.Major impact expected by this proposed research action will be the1. Better access to space-based services developed (demand and supply side) at regional level2. Increased user uptake (e.g. due to removal of language barriers)3. Significantly contribute to growth in the regional market for GMES downstream servicesIn summary, these measures will increase and optimise the benefits of GMES downstream services through demonstrations and an increased awareness in regions. Thus opportunities for raising either public or private funds for further application/business development will be provided. |

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| CermetULtd | Edwin Gevorkyan and Valery Manchesko | Development of new technology of creating ceramic blades with use of nano-powders of refractory compounds for original diskless turbine of advanced gas- turbine engines | Turbines are recognized as structural units of gas-turbine engines, which undergo the highest thermal and dynamic loads and are actively involved in the process of exchange of power and matter with the environment. Such loads result in their earlier damage, as compared with compressors, combustion chambers and other structural parts of gas-turbine engines. In most cases serviceability of such engines depends on the quality and property of materials used to produce turbines. Serviceability of gas-turbine engines is also reduced due to the adverse abrasive and corrosive effects on their turbines of such air environment components as dust, moisture and salt (for marine vessels), as well as sulfur and its chemical compounds contained in fuels used by power-generating and transport facilities<br><br>High gas temperature upstream of high-pressure turbines and high-efficiency systems used for their cooling have become the typical features of the 4th-generation gas-turbine engines. The 5th-generation gas-turbine engines are associated by all the experts with ceramic turbines. Ceramic turbines are recognized as an attribute of such engines.<br>This is due to the fact that ceramic turbines provide for the solution of most of the problems inherent in the 4th-generation gas-turbine engines and, at the same time, allow increasing engineering performance standards and reducing considerably the cost of 5th-generation gas-turbine engines. This is why structural ceramics was engineered by material scientists. On the one hand, diskless turbine rotor blades and nozzle vanes made of structural ceramics withstand effectively adverse environmental effects and do not need to be cooled. The ceramic turbine design having no power disks becomes less complicated, while the material of turbine rotor blades and nozzle vanes promotes serviceability of ceramic turbines, in particular, and 5th-generation gas-turbine engines, in general. | As a result of application of the new engineering concept the ceramic diskless turbine will acquire the following unique properties: As a result of fulfillment of the Project the following intellectual product will be offered to high-tech market consumers to satisfy the demands that were formed more than 50 years ago: the diskless ceramic turbine design wherein ceramic blades will not experience the tensile load effects. The new turbine engineering concept based on innovation engineering ideas suggests a different number of the turbine main structural components and the new approach to distribution of functions between them. |
| CNES | Michel Pons | Micro-Access to space: a challenge for new societal services<br>or How to obtain more services in space with a global system approach. | Future services in space shall more and more benefit from spliting and reorganisation of functions in between geostationary satellites, smaller LEO satellites, UAVs and ground systems. This delocalisation of the system opens the way to a different optimisation approach, allowing potentially responsiveness, safety, performance, and enabling new functional capacities for space systems at much lower costs.<br><br>This evolution corresponds to a similar evolution which has occurred on ground for systems which become more and more part of clouds networks. A similar evolution shall happen for in-space systems.<br><br>In this perspective, work is already undertaken in United States, Russia, Japan and Europe for evaluating the potential of such systems, leading to an impressive expansion of micro-satellites number and capacities. The launcher domain has not followed this trend, remaining focused on ever bigger and concentrated payloads.<br><br>It is proposed to prepare the concept of this missing generation of launchers which shall put into orbit this new generation of space components, i.e. the micro satellites. These small launchers should not be just a replica of bigger launchers. A global functional approach associated to a practical demonstration can give enough evidence and open the way to these new systems, building confidence in technical and financial feasibility for deciding in due time a real system development at space agencies level. | Today, the cost of access to space is the major limiting factor, far before any other factor, including technology.<br>Contribution of Space in environment, communication, monitoring, …and mass consumption of space services is already a reality.<br>Very small satellites, small launchers and a new system approach can reach the goal of decreasing the cost of space services and make them affordable to small sized and innovative entities, private or public. |

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| Collecte Localisation Satellites (CLS) | Aline Duplaa, Jean-Yves Le Bras, Sarka Pavlova | Innovative research to combine space technologies (repositioning and data collection, earth observation, space oceanography) for improved monitoring of marine and coastal habitats and its impact on wildlife | Space technologies have been used for several years to conduct researches in marine and coastal habitat monitoring and related wildlife monitoring in addition to conventional monitoring techniques.<br>Three areas of research can be distinguished:<br>1. Space oceanography and radar-based earth observation help environmental monitoring through provision in near real time of key physical oceanographic parameters, or detection of oil pollutions.<br>2. Satellites transponders relay information and radar based earth observation data help human activities monitoring such as fisheries.<br>3. With regard to wildlife monitoring, a satellite system such as Argos has also been used for three decades to help understanding of displacements and migrations of species dependent of these marine and coastal habitats, bearing in mind that animals are great indicators of pollution threats.<br><br>For the two first areas the combination of space technologies has already been explored in research projects through the FP7, while the last area has generally been addressed separately. In order to better understand impacts on sensitive species of environmental changes and anthropogenic pressure, the following activities could be performed during FP8 timeframe:<br><br>1. Continue FP7 research, where such combination of space techniques will be initiated in projects such as SeaU and SIDARUS for better detection and discrimination of pollutions using satellite radar and optical imagery, set-up of dedicated alert systems, habitat mapping for wildlife interacting with marine zones or sea ice regions.<br>2. Consolidate links between the EU related projects or programmes: LIFE for space based tagging of reference species, Marine Core Services and WISE for marine environment monitoring.<br>3. Establish international cooperation in science innovation and ICT and contribute to the worldwide knowledge base of animal tracking, such as MOVEBANK (www.movebank.org), a web based system for management, sharing, and long term storage of animal movement data. It would be a key research area to further study at European and Regional level the correlation between animal movement data in time and space and high resolution satellite Earth Observation data. | This research will address the major challenges identified in the EU 2020 flagship initiative, Innovation Union, helping to tackle societal challenges such as climate change. This research will be a tool for halting the loss of biodiversity and for monitoring the implementation of Habitats and Birds directives.<br><br>In addition, it will:<br>• Contribute to the development of additional scientific understanding for monitoring the effects of global climate change,<br>• Provide added value to Marine Spatial Planning in order to achieve ecological, economic and social objectives,<br>• Meet the requirements of the EU Marine Strategy Framework Directive for monitoring environmental status as satellite technology offers an ideal method for observing and monitoring environmental changes in the habitat of migratory species,<br>• Contribute to the Marine Knowledge 2020, to avoid data gaps and to develop data sharing, data analyzing and forecasting.<br><br>It is also considered that animals would be ideal ambassadors for the general public to understand the effect of climate change and environmental alterations. There are still a lot of questions to be answered and the correlation between spatial technology and wildlife has proven its time and accuracy efficiency to reply to the scientific questions. |
| CSEM SA | Alexandre Pollini | Distributed smart vision sensors for spacecraft navigation, guidance and control (GNC), and science | Fourteen space agencies have developed the Global Exploration Strategy and created the International Space Exploration Coordination Group (ISECG) in 2006-2007. The purpose of this effort is to prepare humans and machines for venturing further into space, and preparing to establish a sustained human presence in the solar system. To reach these goals both robotic and human exploration is and will be necessary. Several generations of robotic exploration will be eventually required to gain knowledge about target destinations before human exploration can be envisaged. The ISECG has listed enabling technologies that will permit to reach the goals of the exploration programme. A given set of these technologies shall permit autonomous operation and smart decision-making for robotic explorers according to the ISECG. A large variety of technologies and a lot of various expertises must be developed and mastered to build the future GNC systems that will pilot autonomously these exploration vehicles under space environmental constraints. Research and development is needed in several engineering fields to build the future smart vision sensors that will have the characteristics (size, functionalities, power consumption, mass, etc.) allowing GNC systems to fulfill future exploration missions' term of requirements. Progresses shall be made at several levels:<br>• Miniaturization of the building blocks (e.g. laser source, photodetectors, optical microsystems, etc.),<br>• Increase the level of integration (e.g. integrate smart image processing capabilities directly in the photodetectors),<br>• System level (e.g. collaboration of smart distributed elements, co-operation between subsystems, etc),<br>• Experts in the different technologies involved will have to collaborate to build the highly complex GNC systems of the future that will allow the successful autonomous exploration of the solar system. | The number of technologies entering into consideration to build smart vision sensors and advanced GNC systems is large. Additionally, they are so diverse that only collaborations at European level would permit Europe to keep pace with other areas of the world in this domain<br>of GNC systems. Securing new knowledge and solving challenges for space in several engineering areas (micro-electronic, robotic, optical microsystems, distributed systems, etc) will be beneficial for Earth applications as well (e.g. unmanned air, water, ground autonomous vehicles control, natural resources mapping, cities development management, environmental management, etc). Progresses in these areas will trigger limitless possibilities for creativity; hence hopefully allow economic expansion and new business opportunities. It is needless to state that space exploration activities and innovative technologies excite and inspire young generations. |

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| Delft University of Technology (TU Delft) | Zafer Gürdal | Multidisciplinary Design of All Composite Launch Vehicles | High performance fibre reinforced composite materials has found numerous applications in design of lightweight structures including launch vehicles. Nevertheless, so far their use has been limited as a lightweight replacement of components (some of them as major structural components) for traditional designs that are based on monolithic materials. Two important changes in design paradigm should enable to lead completely new designs that will improve performance of launch vehicles. The fist change in design paradigm is the manufacturing integrated structural designs that lead to novel structural configurations. The second change is the integrated multidisciplinary design to combine the design of structural subsystem together with other major subsystems, such as propulsion, thermal protection, and vibro-acoustics subsystems.<br><br>Considering the manufacturing of fibre-reinforced metallic and polymeric composite materials as one of the main disciplines of design, the research to be carried out would treat the design of a complete integrated launch system using the tools of multidisciplinary design and optimization. The research would concentrate on identifying the material needs of different subsystems including the use of metal/polymeric fibre reinforced composites (such as fibre metal laminates), identifying the automated cost effective manufacturing methodologies (such as tow- and fibre-placement machines) that will lead to novel structural configurations (such as grid-stiffened variable stiffness steered fibre laminates), and integrating the functionality of the different subsystems during the design to achieve multifunctional structures that will combine load carrying capability of thin walled with those of thermal protection, propulsion, vibro-acoustic performance requirements. | Cost effective, sustainable and reusable, rapid access to space will be one of the challenges of the next decade as interest in low and high orbit space travel, earth observations, interplanetary space travel is increasing rapidly. Development of lightweight cost effective launch system will enable larger number of private companies who will become competitive in creating business models based on access to space. |
| DLR | Juergen Schlutz | Habitat Research and Technologies for Improving Life Support Cycles | The research will address particularly habitat environments and life support technologies. In that context, promising (micro-)biological systems for air, water, food and waste management shall be identified and developed to breadboard level in a laboratory environment. These systems include e.g. bioreactors and aquatic systems. In a second step, these systems shall be characterized in their mass, working modes and process flows as well as respective interfaces in order to prepare their combination and interoperability with physico-chemical systems. It has to be analysed and described how the biological systems increase efficiency and performance of the overall life support processes. Terrestrial analogue facilities shall be exploited for hardware-in-the-loop tests and qualification in synergy with biomedical and psychological studies as well as with other life support and power generation and storage components. Finally, in a third step, integrated systems for long duration space missions shall be developed and implemented.<br><br>Specific research and applications could be:<br>1) Screening of potential biological systems and processes for air, water, food and waste management in confined space and extreme environments<br>2) Investigation of biological species in life support systems regarding their nutrition potential (e.g. plant mix, aquatic species)<br>3) Investigation on nutrition-optimized versus energy-optimized application of biological systems<br>4) Analysis of potential system linkages and required interfaces<br>5) Conception and operation of terrestrial analogue facilities for long duration closed loop life support analysis and test<br>6) Synergetic linkage of life support and power management systems<br>7) Development of experiments and facilities for in-space research and technology demonstration (e.g. utilization of ISS)<br>8) Identification and advancement of selected microorganisms application to waste recycling and resource extraction | Europe already has a profound expertise in life support systems and habitation technologies. The respective activities outlined above will secure European leadership and strengthen the European role in human spaceflight for future exploration.<br><br>Even more importantly, habitat research and technologies will provide direct benefit to the citizens on Earth and reduce environmental impacts. Better understanding of life support process cycles and their control is directly applicable to a responsible and resource efficient living and industry. The interrelationship of systems and processes for resource provision, utilization, recycling and waste management are analysed, that will considerably influence terrestrial habitation. It will impact first in extreme environments (e.g. resource-scarce and remote areas), secondly in industrial processes (e.g. efficiency, contamination control), and thirdly in day-to-day applications (e.g. waste reduction, energy-efficiency). Specific examples are carbon dioxide monitoring, extraction and processing for pollution control, water filtration and recycling, sustainable agriculture and nutrition provision, waste processing and management. Further potential lies in the inherent synergies with power generation and storage systems like regenerative fuel cell systems.<br><br>These space activities directly involving and being linked to human astronauts in combination with resource efficient and environment-friendly processes are most inspiring for all generations and provide positive impact on the European role in the global community. |

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| DLR Institute of Communications and Navigation | Dr. H. Bischl and Dr. Sandro Scalise | Advanced Transmission Schemes and System Concepts for Space Based Data Relays | Space based data relays are facing special research challenges w.r.t. transmission schemes and system concepts, which have to be addressed to make such systems competitive.<br><br>Satellites are required to enable global connectivity and data delivery with low delay, for certain applications with the highest possible data rates, for other applications with the highest possible availability and robustness against interference. It is therefore of vital importance to develop suitable highly bandwidth efficient and robust transmission schemes. The transmission schemes have to be individually developed for the different application and communication scenarios, e.g. for small terminals with omnidirectional antennas as well as for bigger terminals with steerable, highly directional antennas. Adaptive solutions should be considered to cope with the time-varying communication conditions. Suitable multiple access schemes have to be developed for parallel support of communications links, when many terminals are present. If applicable in specific scenarios, cooperative transmission schemes, MIMO or diversity techniques, or network coding should be considered to achieve the highest possible throughput and availability at the power constraints given in space based data relay systems.<br><br>The optimization of the transmission schemes requires an exact knowledge of the channel characteristics in the different scenarios and frequency bands, including RF and optical frequencies. Suitable channel modelling and if necessary also measurements are therefore a further research challenge that has to be addressed.<br><br>Short term and long term solutions, i.e. systems with already existing satellites and systems with future, more advanced relay satellites, have to be considered to cope with the growing demand for space based data relays.<br><br>In a global space based data relay system different kinds of relay satellites and different kinds of ground stations may be integrated to a common network. The special research challenge for such heterogeneous networks is to develop and optimize suitable ground segment and terminal architectures<br>. | There is a growing demand for global communication access to LEO satellites and airplanes, but also to ships at any time and wherever they are located. The applications behind this demand range from earth observation and surveillance, to telecommand and telecontrol.<br>Terrestrial communication networks cannot comply with this demand, because of lack of coverage. Space based solutions are therefore necessary, and the European Data Relay System is one important answer to this demand. Other solutions, e.g. based on existing satellite systems (like Inmarsat) are also suitable to give access with moderate data rates. Because low and high data rate solutions, and solutions with low delay in the data delivery are demanded, new transmission techniques and system concepts have to be developed and investigated, which address these different requirements individually.<br>The expected impact of the proposed research is to improve the competitiveness of the European industry in this area. Research should be enforced to find competitive and innovative communication solutions both for existing and future relay satellites. It is expected that the inspiration of young researches in this area leads to convincing space based data relay solutions, which save costs and which provide best possible performance. |
| DLR Institute of Communications and Navigation | Dr. Matteo Berioli and Dr. Sandro Scalise | Infrastructure less systems for the collection, the distribution and synchronization of large amounts of satellite data | The use of high-resolution space-based data is essential in many applications, from extraordinary situations, e.g. disaster management (earth observation images), to every-day life, such as management of transportation fleets (automotive, aeronautics, maritime). In most cases space resources are not exploited because we are missing efficient and intelligent systems to manage in a reliable way large amounts of data over long-latency space links. Such data (maps, geo-referenced pictures, lists of node positions, etc.) must be provided in an effective manner. As an example, the space-based earth observation images of a specific region at a specific point in time (e.g. during a disaster) may be distributed only to receivers in that region, thus saving resources (time and satellite airtime capacity) for other users in other regions and at other times. | The efficient exploitation of space resources can enable satellite information services. Europe might take the first steps in this direction, perhaps even before the USA. In addition to energy savings and cost cuts for many companies, these new techniques may generate a new market with a significant turnover, create new jobs and ideas for services. |
| DLR Institute of Communications and Navigation | Dr. Nicolas Perlot and Dr. Dirk Giggenbach | Optical Deep Space Communications | - G22esign of flight terminals that outperforms RF terminal physical volume, mass, power and data rate.<br>- Replacement of expensive large optical telescopes by arrays of smaller telescopes on the ground<br>- Optimization of ground-station networks for optical links in terms of availability taking into account atmospheric quality (clouds, turbulence), local infrastructure and contact time to spacecrafts. | Very high data rates for the download of science data to Earth (downlink)<br>- the EU is significantly behind the USA in terms of deep-space laser communication research and is increasingly dependent on US goodwill. |

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| DLR Institute of Communications and Navigation | Prof. Erich Lutz and Dr. Sandro Scalise | Terabit Satellite Networks | Terabit/s satellite systems will be the next generation of broadband satellites, after the currently evolving new Ka band satellites with a throughput in the order of 100 Gigabit/s.<br>In order to achieve such an extremely high throughput, a large number of questions must be answered:<br>• Satellite systems have to work within a strictly limited frequency band. Therefore, a number of methodologies must be developed to substantially increase the bandwidth efficiency of broadband satellites.<br>• Electrical power and weight of satellites are limited according to the available launch vehicles. Therefore, a number of techniques must be developed to substantially increase the power and weight efficiencies of broadband satellites.<br>These efficiencies must be improved by an order of magnitude compared to present state of the art satellites. This involves a number of detailed tasks that must be carried out within a related FP8 space programme. Here are a few examples:<br>• In order to save bandwidth, the feeder link of the satellite can be implemented in form of an optical link. This would enlarge the frequency band of the user link, if the freed spectrum can be used for the latter.<br>• A higher number of smaller spot beams could be used, to increase the frequency reuse. This, however, leads to an increase of satellite payload weight and complexity, which must be kept within the given power and weight limits. Another consequence of small spot beams is an increased sensitivity to residual satellite movements. The resulting beam wanders on the ground must be taken care of e.g. by new handover protocols. | Studies show that it is much too expensive to cover the last 10% of European inhabitants with terrestrial means, such as DSL or WiFI, than by satellite. Satellite systems, with broadband capabilities are thus needed. They shall reach throughputs a the Terabit/s level.<br>Such systems will help maintaining jobs in rural areas. Additionally, the possibilities for video conferences, and the like will reduce travel needs and thus help saving energy and protecting the environment. |
| DLR, German Aerospace Center | Belabbas Boubeker and Dr. Michael Meurer | GNSS Interworking | The increasing number of independent Global Navigation Satellite Systems (Galileo, GPS, GLONASS, …) is a great opportunity for improving the geographic availability, and reduce the impact of potential failures of anyone of the systems. The best possible benefit is obtained in a full integration of all independent sources in the different independent ground segments. This includes:<br>- The provision of a common time<br>- The common determination of all orbits, and reference station coordinates<br>- The development of a common integrity monitoring systems (for satellite or constellation failure detection).<br>With these improvements receiver's can take full advantage of all satellite signals, and greatly enhance position in obstructed environments, such as urban canyons. Furthermore, Receiver Autonomous Integrity Monitoring (RAIM) algorithms can effectively detect and eliminate corrupted ranging sources, and thus improve the usability in a safety of life context. The latter does not only include aircraft landings of ship berthing, but also automatic digging for canalizations, construction of houses, etc. | The interworking GNSS system will bring more robustness, better availability, and an increased accuracy. Galileo and EGNOS are at the heart of these developments and will evolve by including new services and applications. |
| DLR, German Aerospace Center, Institute of Aerospace Medicine | Gerda Horneck | Astrobiology research on board of the International Space Station in support of space exploration | The environment of the International Space Station (ISS) provides a complex spectrum of physical parameters that are not experienced on Earth and that are of high interest to Astrobiology, a multidisciplinary research field investigating the origin and distribution of life in the Universe. Exposure facilities on the ISS, such as the EXPOSE facilities as well as future payloads, provide unique opportunities to study biological and chemical processes directly in Earth orbit, overcoming the operational difficulties of laboratory simulations. From such studies on chemical or biological reactions to selected extraterrestrial scenarios a better understanding will be reached<br>-* on the role of interstellar, cometary and planetary chemistry in the origin of life,<br>-* on chemical processes on other planets, e.g. Saturn's moon Titan, and possible analogies to the prebiotic chemistry on the early Earth.<br>-* on the role of the ozone layer in protecting our biosphere,<br>-* on the likelihood of the interplanetary transfer of life via meteorites, i.e. the hypothesis of lithopanspermia,<br>-* on the chances of survival of terrestrial microorganisms in outer space, e.g. on a trip to Mars, leading to the formulation of planetary protection requirements,<br>-* on the habitability of Mars by exposing biological samples to simulated Martian conditions (UV-radiation climate, pressure, atmosphere) with and without a protective cover of simulated Martian regolith.<br>Near- to mid-term plans to utilize ISS for astrobiology research have resulted in the development of new multi-use space experiments as well as innovative concepts to study the evolution of biological and organic material inside and outside of the ISS to advance our knowledge on life and habitability beyond Earth. | Europe has gained a leading position in the field of astrobiology studies in Earth orbit, as exemplified by the astrobiology facilities (BIOPAN, STONE, EXPOSE-E, EXPOSE-R, EXPOSE-R2) developed by ESA for Earth orbiting satellites and the ISS, and which are used by international consortia of scientists from European countries as well as from Russia, Japan and USA. These opportunities are unique and the studies have provided basic information relevant for the planning of future planetary missions, e.g. to Mars. To extends Europe's lead in this field it is required to develop the next generation of test facilities for the ISS with sophisticate devices for in-situ monitoring of chemical and biological reactions to the parameters of selected extraterrestrial scenarios, imposed on the test systems.<br><br>Astrobiology research on the ISS is considered as a stepping stone to space exploration, the global challenge for the 21st century. By using the ISS in preparation of this ambitious goal, i.e. an ultimately self-sufficient human presence beyond Earth in search for extraterrestrial habitats, Europe will strengthen its position in the international consortium involved in the space exploration initiative. This will certainly augment the knowledge-based society in Europe, as requested in the European Space Policy. |

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| DLR, German Aerospace Center, Institute of Space Systems | Bernd Biering, Daniele Romagnoli, Peter Spietz | Development of Continuous Low Thrust, High Energy Advanced Propulsion Systems:a) Technology development for solar sail demonstrator TRL7., b) Technology development for Solar Sail Subsystems as part of Electric Sail Spacecraft. | Even though the technological concept for solar sailing has been well known for roughly a century, up to now only JAXA has succeeded in launching and deploying a solar sail S/C (IKAROS Solar Sail demonstrator), which is still struggling with typical demonstrator problems. In the US the Planetary Society's initiative (COSMOS-1) was not successful due to launcher failure. It successor Lightsail-1 passed CDR this summer. NASA's NANOSAIL-D2 was just launched and the deployment is planned for calendar week 47. In Europe this technology is picked up at lower TRLs of 3 to 4 (ESA/DLR: GEOSAIL, Successful on-ground deployment) or with different objectives, as the FP7 project for Cube-Sail, a small scale application, which has the drawback that it can not be scaled up to sizes of typical solar sail missions. Long term visions exist, like DLR's GOSSAMER-Roadmap for Solar Sailing and sail craft subsystem technologies as such are available at quite mature levels (see e.g. Herbeck et al., Sickinger, Eiden, Leipold: European Conference on Spacecraft Structures, Toulouse 2002). But in spite of that no in-orbit demonstration has yet been realised on a European scale. It is proposed to support the development of an European solar sail demonstrator within FP8 with the objective of extending the present technologies to TRL7 (System prototype demonstration in a space environment). This involves optimisation of present boom and boom deployment technologies as well as sail foil and sail deployment technologies with a special focus on scalability to structures of sizes of the order of 100m x 100m, suitable for typical solar sail missions. Cost for the development of a TRL7 demonstrator is expected to be of the order of 20 to 30M€. | Solar sailing is considered among the most promising and efficient non-conventional propulsion technologies. Its ability of providing huge energy to a spacecraft without having to carry the corresponding propellant makes it a very attractive solution for missions requiring very demanding maneuvers, i.e. highly inclined orbits over the ecliptic as for the Solar Polar Imager mission (Dachwald et al., Proc. Astrodynamics Specialist Conference, 21-24 August 20006, Keystone, USA), or non-Keplerian orbits, i.e. polar sitter missions for both planetary and solar applications (Ceriotti and McInnes, Proc. 2nd International Symposium on Solar Sailing, 20-23 July 2010, New York). Being a propellantless propulsion system, solar sailing is also very interesting for sample return missions, since the trajectory's second half could be propelled by photon pressure only, remarkably increasing the available sample mass. Solar sails may contribute to mitigate the space debris problem for GEO satellites, where non operational spacecraft may be moved to the graveyard orbit using only photon propulsion. A solar sail demonstrator could be realised by 2015 enabling an operational solar sail mission up to 2020. This will be an enormous asset for both the European scientific and industrial communities, representing at the same time a breakthrough in space exploration activities. |
| DLR, German Aerospace Center, Linder Höhe, 51147 Köln, Germany Institute of Aerospace Medicine | PD Dr. Ruth Hemmersbach, Prof. Dr. Ralf Anken, Dr. Petra Rettberg , Dr. G. Reitz | Use of Space and Planetary Simulation Facilities as testbeds for gravity, radiation and other extreme planetary and space parameters | Ground based experimental platforms have been developed in order to prepare space experiments and to get basic knowledge on the impact of gravity, radiation and other extreme planetary and space parameters on biological systems: clinostats, random positioning machines, levitrons in order to achieve (functional) weightlessness conditions, various centrifuge devices to provide hypergravity conditions, X-ray source with respect to simulate the ionising radiation in space, UV source as solar simulator, planetary and space simulation facilities to mimick the harsh environmental conditions in space and on other planets and moons of our solar system. Hitherto, various kinds of these facilities are used to, e.g., simulate weightlessness. It has, however, still to be proven to which extent such facilities indeed show effects similar to effects of real space and planetary conditions, e.g. microgravity or the specific UV climate on Mars. Thus, comparative studies using a variety of different biological model systems are sorely needed. Such studies would be able to identify the optimal simulation technique for a given model system. Therefore, not only the usage of theses devices as a prerequisite for space experiments should be funded but also comparative studies using different kinds of simulation approaches in order to understand what happens mechanistically doing exposure. Furthermore, ground-based studies on bioregenerative life support systems are a prerequisite for space exploration. | The unique possibility to have access to space conditions and thus studies of the impact of gravity, radiation and other extreme space and planetary parameters on life is clearly a basic research. The rare and expensive space flight opportunities and the limits in mass, space and energy for each space experiment exacerbate biological investigations due to the need of several sample replicates and experiment repetitions. Therefore, the corresponding ground research is very essential. The topics as well as the technological challenges fascinate and attract also young people. Possible applications might be in the future of therapeutical relevance with respect to the understanding of the altered/ disfunctioning of signalling pathways in living objects. Long-term exposure to space condition (exploration) demands fundamental preparatory studies. The future success of life science research in space does not only depend on the availability of specialized research facilities and infrastructures, but also on the continuous development and integration of new technologies to equip these facilities. Such projects will constitute an opportunity to strengthen the link between users (researchers) and designers (often engineers) for the specification, design, test and operation phases of technological developments. |

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| DLR, German Aerospace Center. Institute of Communications and Navigation | Boubeker Belabbas | Global Navigation Satellite Systems (GNSS) for Autonomous Relative Navigation | Formation flying of satellites, or unmanned aerial vehicles, column driving of rovers guidance of shipboard landings have all a common target i.e. to ensure a robust relative postioning between 2 or more vehicles in order to achieve a specific goal. One of the most important benefit of that is the possibility to improve the traffic management, to optimise the fuel consumption, to reduce the gaz emissions, to assist the pilot/driver and therefore to improve the comfort and ergonomy of passengers.<br>It is needed to investigate in a mathematical way an extended concept of navigation integrity: A network based integrity concept, providing safety, efficiency and respectful of the environment.<br>Investigation of a total system performances taking into account not only the navigation system but also other sensors (Inertial, radar, video camera, …) and the integration with autonomous control (Autopilot, automotive assistance).<br>Propose a demonstration to illustrate the success of the project. | The increase of air traffic management (should double in the next 15 years), the increase of transport capacity and the need to reduce costs, will necessitate to optimize the management of vehicles and develop smart automatic systems able to communicate with each others and take decisions in a consensus manner. News services will be created around this concept and will have a positive impact on time efficiency, optimized control law to reduce time, costs and to create new activities for Europe. As this is an advanced, challenging area, this will be a factor of motivation for many students. |
| DLR, German Aerospace Centre, Institute of Communications and Navigation | Dr. Michael Angermann | Planetary surface navigation | Europe's plans for exploring our solar system and even beyond, as laid out in ESA's cosmic vision programme, are serious and ambitious. Europe is striving to take a leading role in sending robotic probes to places where no one and nothing manmade has gone before.<br>In order to operate these probes and interpret their findings, accurate knowledge and control of their position is of utmost importance. We need to be capable of determining positions and attitudes of such probes on the way to planets and asteroid, during their landing and on the surfaces. While absolute positioning is important, precise relative positioning of these probes with respect to the observed features and to other probes is extremely challenging and even more relevant to the scientific outcome. We propose to develop algorithms and systems that incorporate sensors, such as cameras for relative positioning in these the environments and to combine these sensors with cooperative radio navigating among swarms of space probes. | Europe's space industry is coming up on par with the current leaders (US, Russia) but faces significant competition from newcomers, such as China or India. The exploration of the solar system is at its beginning and is likely to inspire strong interest from mathematics, physics engineering, biology and chemistry.<br>The capability to navigate is one of the key enablers of future missions and a component needed for virtually all future missions. A technological lead in this domain can be achieved and would significantly strengthen Europe's space industry, resulting in a significant number of highly qualified experts and jobs. |
| DLR, Institute of Aerospace Medicine, German Aerospace Center | Prof. Jörn Rittweger | Utilizing augmented reality and virtual reality in order to enhance human performance in space exploration | Human exploration of space, be it in low Earth orbit or future lunar or other missions imposes huge challenges. In particular, isolation, monotony, and the lack of social contacts lead to psychological deprivation, which are likely deteriorate human performance, including the potential for mis-judgement of hazards and personality alterations. Ultimately, all these factors can potentially jeopardize mission success.<br>Augmented reality (AR) and virtual reality (VR) offer a possibility to modulate and enrich human perception and consciousness. They could be used to supply stimuli to individuals under controlled conditions, and to thus counteract sensory deprivation and isolation in a meaningful way. Application of such an approach clearly has great potential for application for spaceflight missions, but also under terrestric conditions where emotional and cognitive well-being are at stake.<br>Research should therefore be solicited to explore the potential of AR and VR to sustain and enhance human performance in activities that are crucial in manned exploration missions. In particular, the potential of AR and VR shall be explored to enhance and safeguard motivation alertness and error detection, emotional stability as well as physical performance capacity, and also the ability to communicate and to interact socially. Moreover, AR and VR should be tested in order to enhance motivation for those elements in missions that require high levels of personal commitment. | Human space exploration constitutes an extreme example of the psychological challenges to human performance in terms of isolation, monotony, and the awareness of the potential for hazards. Moreover, high levels of personal commitment are often required. Although dissimilar in the physical context, there are already now many ground-based working conditions that face very similar challenges in this context. Examples of this extend from expeditions, e.g. in the arctis and antarctis, where isolation and personal commitment are probably the greatest challenges, to the work on oil platforms, but also in the army, aviation, in hospitals, traffic and in many other working environments where the combination of monotony and inherent risk-taking give rise to potentially great hazards.<br>It is evident that any solution of these psychological challenges in the context of space missions will greatly benefit these ground-based areas. |

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| DLR, Institute of Communications and Navigation | Dr. A. Dreher and Dr. H. Bischl | Advanced Beamforming Techniques | A number of new techniques have recently been proposed for enabling efficient data communication with fixed and mobile users. Katrina triggered the development of ground based beam forming in the US, and the launch of satellites with antenna reflectors as large as 18 meters. Corresponding technologies and algorithms must be developed in Europe.<br><br>Additionally, new options open up with sample based on-board processing techniques. They are capable of maintaining the same signal transparency as analog systems but nevertheless benefit from steering and interference suppression capabilities. | Satellite systems must make an efficient use of the available spectrum, as well as of the power generated on-board of the satellite and of the heat that needs to be dissipated into space. This requires that the right amount of power flux must be directed to the intended users and no others. Furthermore, the interference from a dense frequency reuse must be handled. All of these factors are crucial to the further utilization of satellite communications in the context of ever increasing data rates. These capabilities are needed in isolated rural environments, in the air, and after disasters or other infrastructure disruptions, and other domains. |
| DLR, Institute of Communications and Navigation | Dr. Achim Hornbostel and Dr. Michael Meurer | Robust GNSS Receivers | In the recent past initial results on array antennas and array processing have been obtained for interference and multipath mitigation in GNSS receivers. Simulations and first demonstrations in real environments show a promising performance in interference and multipath environments. The combination with time and frequency mitigation techniques is extremely promising but has not been much addressed. Such techniques include joint multi-frequency, multi-satellite code and phase tracking, as well as the suppression of interference in time and frequency domain before despreading. Other open problems include the control of the phase centers, in order to ensure millimetre accuracies, as well as the question of integrity. If such algorithms are to be used in a safety critical, they must be certified, which imposes certain constraints on their structure.<br><br>Detection and mitigation techniques must be adapted to the specific characteristics of different interference sources and user environments, e.g. they are different for pulsed and continuous interference or for narrow band and wideband interference. | Robustness and reliability of GNSS receivers against unintended interference and jamming and multipath propagation is essential for the introduction and acceptance of Galileo and its services into new user domains, e.g. CAT II/III landing approaches in aviation, fluvial and harbour manoeuvring, terrestrial navigation and control tasks and automation. This includes both interference and multipath detection with respect to the system integrity as well as mitigation techniques in order to keep the service availability and continuity even under disturbed signal conditions. The development of techniques to fulfil these requirements will create new jobs in the GNSS sector including receiver manufactures, research, and development of applications. If robustness of receivers can be achieved, the introduction of GNSS into specific applications, which are now maintained by other means, can also help to save energy and to protect the environment. For instance, compared to current instrument landing techniques, landing approaches with GNSS will allow more flexible and variable flight patterns, which can be optimized with respect to energy consumption and noise protection of the airport surrounding environment, and can also increase the airport capacity. |
| DLR, Institute of Communications and Navigation | Dr. Thomas Dautermann and Dr. Michael Meurer | Deep Space Navigation | Usability of stellar phenomena (Pulsar, Quasar, Stars etc.) as ranging sources to triangulate positions, here especially detection of signals w.r.t. background noise, timing, etc.<br>- Satellites orbiting each individual planet in the solar system (positioning system for the respective planet) radiate also into space and could be used as a solar satellite positioning system<br>- Planetary satellite navigation systems to be used for navigation during exploration of new planets (constellation of one or very few satellites – Doppler positioning, like in TRANSIT?)<br>- Interstellar navigation through optical comparison of star constellations | It is crucial and necessary for future space exploration beyond the moon that precise navigation is guaranteed. As the spacecraft moves further away from the earth, guidance signals from the operations centre only reach the spacecraft with long delays (Earth-Mars 4 minutes, Earth-Jupiter 35minutes) so that the vehicle must navigate autonomously.<br><br>Europe does not want to completely depend on the USA in space exploration, and thus needs to address these issues. |

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| DLR, Institute of Communications and Navigation | Jens Hammesfahr and Dr. Michael Meurer | Advanced GNSS space segment | The evolution of the space segment of Galileo is crucial for improving the positioning performance and overall cost of service provisioning. Two-way intersatellite links can improve the positioning accuracy (the atmosphere is not involved in the measurement of propagation delays), and increase the system autonomy, by supporting direct data exchanges. The ultimate timing system would be obtained by flying optical clocks that are connected by optical links. In a closer future, the robustness of the satellite timing system can be increased by the use of an on-board composite clock. Furthermore, on board integrity monitoring will accelerate the detection of anomalies.<br><br>The future constellation, might be augmented by a small set of HEO satellites. LEO and GEO satellites used for earth-observation, and communications, respectively, might include payloads, to increase coverage in urban and other difficult environments. | Galileo should offer a level of service at least equivalent in performance to GPS. GPS implements intersatellite links already, and is conceiving other advanced capabilities for GPS III and beyond. The present work shall ensure that Europe finds the most useful ways to evolve its system, to the best advantage of its citizens, industry, and scientific community. |
| EADS Astrium | Brigitte Serreault | "sustainable space": debris removal, space assets Protection, green manufacturing, SBSP etc 2. EU new strategic missions 3. Space transportation and space exploration future technologies.4. demonstration and H27 projects (high TRLs) | Sustainable space:<br>Beyond the contribution of space to environment monitoring, the whole cycle of space missions must become "sustainable": ground manufacturing and testing, in-orbit operations, end of life (solar sails for deorbiting, large debris capture…), equipment recycling or reuse. This includes environmentally friendly components such as new metallic and composite materials, including resins, propellants, energy generation and storage, and the debris reduction:<br>- For launchers: on-board devices to activate automatically the destruction of the launcher in case of anomaly of the trajectory of the launcher or on-board devices for launching and transfer monitoring,<br>- For spacecrafts: board protections against collisions, reconfigurable architectures, fractioned missions, black boxes,<br>- Devices of debris reduction: elimination of big debris (destruction, collection, deorbitation) and associated computing means to simulate generation and propagation of small debris,<br>- Generation of "green energy", by space based solar power or smart power grid management including smart metering systems.<br>An important new issue is the legal field.<br>This is triggered by the debris management issue but encompasses many domains such as a possible EU space law, the freedom of access, the cleaning necessity. Financial mechanisms such as deposit may appear for satellite operators, insurance domain is also tackled by this new topic. On top of that, the multiplication of space systems in ordinary life will raise legal issues; legal value of space data - images, navigation, time, telecom channels.<br>EU strategic future missions<br>In these missions, the EU may have a key role to play in the system architecture, control and operations, involving the security main players:<br>- Space critical infrastructures protection (space and ground) against collisions or physical or cyber attacks.<br>- EU space assets surveillance and protection systems,<br>- debris removal from the ground (laser) and from space (non-cooperative rendez-vous, etc).<br>- Security EO missions:<br>- Very High Resolution GEO observation for humanitarian and security for instance,<br>- SIGINT missions (for maritime or border security, etc).<br>Preparation of future missions<br>This must be supported by filling important technology gaps:<br>- flexible launch systems architectures,<br>- innovative transportation strategies, i.e new navigation for freight or unhabited missions, on board energy generation (new ergol storage, new power sources (TEG), safe "nuclear" power generation for the future long duration missions),<br>- exploration (robotics…),<br>- life support technologies | 1. Sustainable space contributes to the global environment and the perennial use of space, especially for the EU space assets and the space industry..<br>2. Strategic missions contribute to the EU security and international policy.<br>3. Technologies for future missions guarantees the EU space autonomy in the future.<br><br>All of them will contribute to maintain and create employment in the space industry and SMEs and will tighten the links between the private sector and academia and will involve new MS players. |

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| EADS CASA Espacio | EADS CASA Espacio | Complexity based design of Space Systems | 1. Space Systems are a classical example of complexity. Many of the failures of those systems are linked with their intrinsic complexity (small or simple failures can provoke an overall one with mission loss). A margin based design – with redundancies - tries to avoid those failures.<br>2. There is an alternative approach: studying the behaviour of the system – by means of its measured performances or the simulated ones taking into account the scattering – it is possible to try to measure its complexity and to know the ability of the system to survive against environmental changes (see http://www.oensys.com/). This methodology is currently applied to study the stability of economical entities or the one of patients under heart surgery.<br>3. The proposed research will focus on measuring complexity and apply it to Space System design with particular emphasis on space launchers and their missions. | 1. European research was pioneering the stochastic design of mechanical systems by developing PROMENVIR (under 4th FP) and SCAT (also 4th FP) and the complexity metrics and applications are based on those developments. Current complexity metrics are based on those developments.2. Nowadays there is a possibility to become also the first ones applying this novel methodology to the study of a Space System as an example of a general complex engineering one, opening new ways of designing complex engineering systems and missions. |
| EADS CASA Espacio | EADS CASA Espacio | Wireless Data Transmission inside and outside launch vehicles | 1. Current design of avionic systems in European launchers uses extensively connections by classical metallic harness, both inside the launcher and between the rocket and the launch pad before ignition of the engines.<br>2. This type of design implies high mass and complexity in the separation of the different stages.<br><br>The proposed design will explore all the possible alternatives to substitute the wired connection by the most modern wireless ones including WiFi and Optical based ones (directional laser and diffuse light ones), selecting the most appropriated for the launch vehicle. | 1. There is not a wireless design in any current launcher: this is a real opportunity of having a state-of-the-art design in a European spacecraft.<br>2. This research is compatible with the foreseen development of a new European launcher (to be qualified in 2025) and constitutes a clear competitive advantage of it. |
| EADS CASA Espacio | EADS CASA Espacio | Environment Friendly Structural Elements for Launchers and Spacecrafts | Current structural space elements (mainly made from Carbon Fiber/epoxy) separated from the spacecraft main body, have an environmental impact not only inside the Earth atmosphere in terms of contamination, but in the outer space in terms of space debris.<br>Both sources of pollution could be suppressed from the launch vehicles, or at least significantly reduced, by using specific approaches:<br>- Those elements to be released inside the atmosphere should be avoided by design and made from more environmental friendly materials to avoid any contamination of the ground.<br>- Those elements to be released in the outer space must be as less as possible in number of them and should be able to be disintegrated when crossing the atmosphere.<br><br>A line of research for each one of the mentioned situations should be opened in combination with the main parameter of every launch vehicle or spacecraft: the lowest possible mass. | In the last years we all have been witnesses of the increase of the importance of the sustainability for any kind industrial activity. The spatial domain has been always in the state-of-the-art in terms of material research, and at this moment, the research has to focus not only on the increase of the materials performances, but in minimizing the contamination impact associated to their use.<br>Beside this, European laws are in constant modification in the direction of protecting the environment (i.e. REACH law), so in order to maintain the balance between development and environment protection, the European research efforts should be oriented in the study of materials that could achieve a good compromise between both aspects. |
| EADS CASA Espacio | EADS CASA Espacio | Structural Materials and Processes for High Temperature Applications | 1. Current structural space materials (Aluminium and Carbon Fiber/epoxy) have a service temperature less than 150ªC. Though this service temperature is met for most of the current applications, new missions and applications are demanding to withstand higher temperatures:<br><br>2. Earth atmosphere Re-entry vehicles , like reusable launchers, Space Station Cargo and Crew transportation.<br>3. Planetary Exploration vehicles, like all the landers.<br>4. Expandable launchers, to reduce the mass and cost associated with thermal protections.<br><br>The basic research should go directed to develop new organic polymers in combination with carbon or new fibers, and study its processability and manufacturing feasibility for Space Applications. | It is essential in order to:<br>- Avoid dependability from US materials investigating in this field.<br>- Reduce mass of the thermal protections, specially for interplanetary missions, to increase the payload mass.<br>- Assure further reusability of spacecraft components, (launchers stages and cargo transporter) to reduce the debris in Space |

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| EADS-CASA Espacio | J. Guillamon and P. Lario | New materials and processes should allow affordable access to Space. However, it requires R&D activities to optimise current design process and implement new and more environmental friendly materials. | 1. Revisit the current design and analysis process to reduce costs and schedule with respect current standards.<br>2. Characterisation of new materials, more user friendly with better performances and lower costs.3. Implementation of WiFi and Wireless communications networks inside satellites and launcher will bring significant cost and mass saving wrt current cupper-based standard communication harnesses. | 1. New materials will allow a lower environmental impact and will secure an independent sources wrt other countries (i.e. US ITAR restrictions)<br>2. Proposed R&D activities will allow a more affordable access to space while keeping European R&D institutions in a leading position at technology level. |
| EFACEC | João Costa Pinto | Radiation monitoring and solar flare detection. | Reduction resources of radiation monitoring are necessary since the current capabilities are occupying too much room, weighing too much, consuming too much energy.<br>High resolution to capture e.g. Solar Particle Event or radiation belt variabilities; coarse resolution for quiet time background e.g. during cruise phases. Depending on the accumulation period chosen the communication data rate shall be adjustable.<br>Logarithm dynamic range is a must to enable higher range of energies detection.<br>Improvement of particles discrimination is also required.<br>For these purposes it is necessary to design a new ASIC able to perform fast as required and with high noise rejection.<br>It is required to define a set of detectors able to cope with the required energy range and the particles types.<br>A design program followed by a qualification campaign is necessary in order to allow the production of flight units able to be applied in satellites and or other spacecrafts.<br>ESA projects and consortia of several European companies can be improved by the usage of additional funding. | Space activity is essential for life on Earth and Space exploration. Space radiation is a concern in every mission in particular when manned missions are in stake. Therefore it is necessary to be aware of the energetic particles that can damage hardware in Space, disturb the Software or injure Astronauts. The budget available from ESA is not enough for this development and additional aid is necessary. |

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| European Low Gravity Research Association, ELGRA | Dr.ing. Jack J.W.A. van Loon | Microgravity related research within Europe. | Although the initial steps in space flight and microgravity related research have traditionally been set by Russia and America, Europe has gained more and more interest and involvement in this line of research. More recently also China has entered this field of activity also as a means to foster and expand on the science and technology capabilities in this upcoming economy.As Europe we have a strong interest and track record in (micro-)gravity and space related research and technology. Various countries have their national space programs and larger activities are carries out trough participation in ESA programs.Although the contribution of ESA and some National Agencies to the International Space Station, ISS, provides access for European scientists to the ISS to perform their science, the research capacity and other limitations are still quite significant. On the other hand, research capacities in countries like China but also the USA with their strong program in commercial space flight will encumber Europeans' current and future position in this field.In the FP8 hearing we would like, as European Low Gravity Research Association, ELGRA, to bring forward the general comments we received from our membership regarding the new FP8 program. We will present the feedback on issues for ground based and space flight research capabilities in Europe for microgravity related studies and what the role of an FP8 program could be to improve this. | Space programs including human space flight and microgravity research and technology is an important drive to a communities' innovative and educational capacity. The microgravity environment of space provides a unique platform to perform studies in physical and life sciences and technology. Understanding processes in fluid behaviour, material and plasma physics, human physiology and plant and cell biology are important for basics knowledge but also for application in society. Adaptations of the human body to space are not well understood and more research is needed. What we presently do understand is that astronauts' body adaptations have several similarities to the process of ageing. An ageing is population is one of the challenges Europe is facing in the coming decade. More knowledge is required to understand and tackle this problem economically. Protocols and technology developed through a dedicated European Space program will support such an effort. The space program and especially human space flight and exploration has always been an huge inspiration for youngsters. Space and microgravity related sciences should be used more to have young people engaged in science and technology within Europe. We would encourage the commission to have a strong program on this in coming FP8 activities. |
| European Union Satellite Centre | Juan-Luis Valero, Denis Bruckert, Jean-Charles Poletti, Andrea Patrono | Operational space security challenges to support the CSDP (Common Security and Defence Policy) in 2020. | In 2010, ten years from now, the EU will probably be engaged in complex and distant endeavours making use of a wide spectrum of instruments underpinned by space assets and its associated technologies. In particular, the entry into force of the Lisbon Treaty creates the European External Action Service and identifies Space as a shared competence between the EU and its Member States.<br><br>Most probably in 2010, situation awareness from space and of space will employ a wide range of information derived from space, aerial ad in situ sensors exploiting a large region of the electromagnetic spectrum with an increased spatial, spectral and temporal resolution. Traditionally isolated space applications such as Earth Observation, Communications and Navigation will be integrated supporting multi level decision-making ranging from strategic planning to operations on the field.<br><br>Following the above-depicted scenario, the exploitation and dissemination of very large and heterogeneous information sources will be a key challenge, which could be tackle from different perspectives, such as:<br><br>a) The optimization of the use of space assets (e.g. GMES/GALILEO) that by its own nature have a dual character.<br>b) Decision support systems within the information workflow, from data gathering planning up to information's dissemination.<br>c) Independently of the information source / exploitation process, the final assessment of situation awareness is made by a person, probably the scarcest resource. Proper training/knowledge management will be a key challenge to keep pace with technological developments.<br><br>Finally, considering the increased dependence of Europe and its Member States from space, the protection of its space assets and the operational use of space situational awareness will continue to be a challenge in the 2020 framework. | Space assets are essential for the activities of modern societies. Communications, navigation, positioning and timing, meteorological services, geospatial information, understanding of Earth environment and civilian and CSDP operations to name just a few services, rely on space assets. The integrated use of those resources translates into more efficient responses, saving costs to be paid by the European Citizens.<br><br>In the case of civilian and CSDP operations, addressing of the above research challenges could provide the means to better fulfil their mission, providing superior and faster decision making results as well as a reducing the risk onto deployed personnel. |

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| EUROSENSE BELFOTOP N.V. | Nathalie Stephenne | Increasing European security in addressing International human risks by combining remote sensing data with socio-economical information | Space technology should be able to provide accurate, timely and relevant information to better understand and measure Human Security. Human security deals with risks occurring to people. While remote sensing information inform precisely about extent and exposure to specific risks, the link to the specific population is still a critical step for future research. Knowing where people are and if they are vulnerable to specific risks are two major research questions that are still to be addressed by European projects.<br><br>To address the first question population distribution models should be developed. Population density map integrates demographic data from statistical sources with land use information. This spatial link to population data is an initial step to other socio-economic statistics. While population information is of poor quality, models assumptions help to identify the spatial pattern of the distribution by indirect factors. Land use information is crucial in such model.<br><br>The second question refers to analysis of risks and vulnerabilities. Geospatial technologies provides already technological support to authorities in the prevention and post-crisis management phases of emergency cycles such as flood, industrial crisis, earthquakes, … Geospatial tools are developed to better represent energy linkages, water flows and risks, urban sprawl and imperviousness of European cities. Their application to address issues outside of Europe needs to refer to local specifications as well as global challenges such as climate change. Remote sensing products should for example be adapted to help the decision makers to improve forest conservation (Reducing Emission from Deforestation and Degradation – REDD). | Remote Sensing products developed through GMES research projects at the European level should be extended and specifically developed to address International Human Security. For humanitarian aid, development and environmental reasons, European Commission should get technical spatial information about risk to human. This means to make the spatial link between population/ assets and risks. Human security research would allow Europe to address issues in its Neighboring countries but also global challenges such as climate change and forest conservation. Geospatial technologies promote European research in developing countries where accurate information is significantly missing. Geospatial technology related to human well-being can support the European policy on the International sphere. |
| Eurospace | Pierre Lionnet | Taking European space technology to next stage; A programme to bring European space technologies to the appropriate maturity level for implementation in European systems for dependence reduction and risk mitigation. | The space sector is strongly technology oriented. Space systems seek to optimise technological choices balancing safety and reliability aspects (maturity and predictability), with maximum performance (state of the art and innovation):• Space sector is a demanding technology integrator (uses innovation and research concepts developed for other sectors) • Space sector is also an innovation 'driver' (drives technology development for unique uses, pushes the limits of technology and novel concepts). For technology integration the space sector takes technology with proven/promising concepts (TRL 2 to 4) and needs to produce incremental developments to bring it to TRL 6-9 for use in space programmes. • E.g. CCDs, memories, FPGAs, DSPs, solar cells, batteries, MEMS/MOEMS (actuators and sensors), materials (composites, Shape memory alloys) etc.This incremental development is usually done in two stages:• TRL 2-3 to TRL 4-5: component/breadboard validationo this stage of development is currently pursued by ESA in its CTP, TRP and GSTP programmes (addressing TRL1 to 5 globally). • TRL4-5 to TRL 6-9 (depending on qualification requirements): from breadboard to flight model and prototype/system qualification in space (or on ground). o There is no coordinated approach to support technology maturity and qualification at European level. This final stage of qualification is often performed on-board the actual mission (with a risk for the mission).With a growing number of space applications (meteorology, telecoms/broadcast, navigation, environment/resources monitoring) the requirement for technology reliability (and maturity) is progressively imposing itself, as more users learned to rely on space systems for actual services provision. To support the continuity and development of space applications, technology strategies need to give the appropriate attention to technology maturity aspects, to ensure that technical advances and consolidations are translated into products and services. Reaching the latest stages of maturity would ensure that European state of the art technologies can be safely implemented in programmes. • Maturity: a bridge over the valley of the dead - TRL gap, maturity for promising technologies (from science and technology to Innovation). Address low level building blocks, generic technologies, EEE components... Bring technologies from TRL 4-5 to TRL 6. This programme would also be used to support standardisation of interfaces, and product reusability. • Qualification: An annual qualification plan – with a coordinated plan of 2 launches a year (or more) for 'technology satellites': satellites embarking new technologies and building blocks to qualify them in the appropriate space environment. The programme could fund the launch service, the platform procurement, and the spacecraft integration (as an infrastructure). The programme participants could provide the experiment/technology with a co-funded scheme (research). Such a programme could qualify 15-30 new European technologies every year (and more with more launches). | A technology maturatuon programme, aiming at ensuring the readiness of European space technologies for implementation in European space programmes will bring the following direct benefits:• Systems improvement: enhanced applications• Increased confidence in space technologies: Risk-free state-of-the art technology implemented in operational systems • Dependence reduction: there are (particularly in the EEE domain) many European technologies that are never given any chance to fly due to their low level of qualification. US technologies are used instead, creating dependence. Increasing their maturity will put them on a par with US competition .• Industry competitiveness: with more mature products and technologies the European space industry will exhibit a more robust profile and will be able to step up its supply. • Give a chance to new concepts and newcomers • The programme could have a positive structuring effect on the European space test infrastructure.Indirect benefits:• Provide an institutional market base for the VEGA launcher• Increase visibility to EC Space policy (esp. if EC financially supports CSG) • Attract the young: the Annual Qualification Plan could be used to give an opportunity to academia to fly student payloads, giving a boost to the attractiveness of science and engineering careers for the young. |

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| Finnish Meteorological Institute | Pekka Janhunen | Development of electric solar wind sail propellantless propulsion for solar system access | The electric solar wind sail is a new propulsion method which was invented in Finland anduses the natural solar wind for producing spacecraft propellantless low-thrust in-space propulsion. According to published estimates, the electric sail can provide about 1 newton continuous thrust from a 100 kg system which is 2-3 orders of magnitude higher performance (in terms of lifetime-integrated total impulse per propulsion system mass) than what chemical rockets or ion engines can provide. The electric sail will be developed to TRL 4-5 level by the ESAIL FP7 project (2011-2013) and two CubeSat test missions (ESTCube-1 in Estonia, launch 2012, and Aalto-1 in Finland, launch 2013) are under construction to measure the electric sail effect in low-earth orbit. The next logical step after 2013 to develop this revolutionary European space propulsion invention would be a test in the solar wind, to raise the TRL to 7 and higher, at estimated cost of 20-30 Meur. To scale the technology up to full-scale production missions, the manufacturing capability of thin, conducting tethers also needs further support (some millions). | The electric solar wind sail is a disruptive technology which was invented in Europe and which may completely revolutionarise our capabilities to access the solar system because of its groundbreaking performance level (2-3 orders of magnitude improvement). The electric sail could be used for very diverse applications such as multi-asteroid touring mission, flight out of the solar system at more than 50 km/s speed, off-Lagrange point solar wind monitoring, sample return from targets such as Mercury, etc. It could also be utilised commercially in terms of solving the transportation bottleneck that has thus far prevented the development of advanced applications such as asteroid resource utilisation and the use of asteroid-derived fuels and materials for large space constructions (e.g., solar power satellites for clean and abundant energy). The electric sail solar wind test and demonstration mission could fly in 2015 and the first production mission could fly before 2020. Development of the electric sail technology for solar system access would be a historical achievement that would expand the human horizon for generations to come and unlock a large development boom of qualitatively new types of scientific and commercial activities in the solar system. |
| Finnish Meteorological Institute, German Aerospace Center DLR, Institute of Space Systems | Pekka Janhunen, Bernd Biering, Peter Spietz | Development of Continuous Low Thrust, High Energy Advanced Propulsion Systems: b) Technology development for Solar Sail Subsystems as part of Electric Sail Spacecraft. | The novel technology of Electric Sailing was invented in 2006 in Finland. First technological studies are very promising and presently a EU FP7 project is under realisation, which focuses on the development of a TRL4-5 level ("breadboard plus") system of this technology.<br>The current baseline idea of implementing the electric sail is with auxiliary tethers for automatic centrifugal equalization of the main tether separations (so that no moving parts are needed for control during flight) and with cold gas thrusters for the initial spinning up and later spinrate control.<br>An alternative solution would be to use small solar photon pressure sails (centrifugally stretched or inflatable "solar blades" with few square metre area each) at the tip of each tether, possibly with redundant units for high reliability. One would then also have the option of leaving out the auxiliary tethers and to rely entirely on the solar blades for the control of the spin state of the main tethers. The resulting electric sail propulsion system would not only be immensely powerful (as all electric sails), but also elegant, simple and very scalable. The solar blade concept can be validated with a low-mass single-tether orbital demonstrator and it could also be used for controlling the spurious spinning of an IKAROS-type photon pressure sail caused by the random wrinkles of the main sail. We propose to develop within the FP8 programme a solar blade guidance system for electric sails and IKAROS-type solar sails. This would provide excellent synergy with proposal (a) Technology development for solar sail demonstrator TRL7 (handed in separately), in addition to continuing and complementing the present FP7 electric sail technology development effort. | The electric solar wind sail is a disruptive technology invented in Europe and which may completely revolutionarise our capabilities to access the solar system because of its groundbreaking performance level (2-3 orders of magnitude improvement). The electric sail could be used for very diverse applications such as multi-asteroid touring mission, flight out of the solar system at more than 50 km/s speed, off-Lagrange point solar wind monitoring, sample return from targets such as Mercury, etc. It could also be utilised commercially solving the transportation bottleneck that has thus far prevented the development of advanced applications such as asteroid resource utilisation and the use of asteroid-derived fuels and materials for large space constructions (e.g., solar power satellites for clean and abundant energy). Combination with solar photonic sail technology makes it an elegant, scalable and with both techniques being propellant-free consistent system.<br>A demonstrator mission could be realised by 2017 and a first combined mission could fly before 2020. Development of this technology for solar system access would be a historical achievement expanding the human horizon for generations to come and unlocking a large development boom of qualitatively new types of scientific and commercial activities in the solar system. |

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| GDAF-UC3M, Dep. Tecnología Electrónica, Universidad Carlos III de Madrid | Ricardo Vergaz Benito and Alberto Carrasco Casado | Optical communications for high-rate near-Earth and deep-space data links. | The next generation of spacecraft will need faster telecommunications links. Links between remote sites such as planetary orbiters, Earth satellites, etc. should deal with bigger and bigger amounts of data to be transmitted. Traditional radio links are handicapped by the divergence of the beam with the distance, limited spectrum, and other problems. In order to satisfy the increasing demand for bandwidth, the usual strategy has been moving to higher and higher carrier frequencies. The move to optical frequencies means a qualitative leap because it provides a shift from tens of GHz (Ka band) to hundreds of thousands of GHz (wavelength of 1 μm), lowering the signal divergence by four orders of magnitude. Lower divergence allows higher reception power and signal-to-noise ratio, enabling faster communications with lower bit-error-rates.<br><br>The development of optical communication technologies on board spacecraft has been slowed down by obstacles like the difficulty to compete with the consolidated RF technology, and the resistance to introduce new technologies in the space industry. However, the development of optical communications in space will be unavoidable as communication needs become strategic for future spacecraft. The most relevant space agencies agree on that now.<br><br>The move to optical frequencies involves a shift of model in communication system design; because all parts on the physical layer differ from those used with microwave links. Some of the technologies to be researched in Europe in order to become leader in this effort include accurate pointing and acquisition technologies, fast and stable optical gimbals with controlled and minimal divergence, solar radiation background filtering, fast-response detectors and amplifiers and fast coding and modulation technologies, single-photon detection, telescope array and its synchronization techniques, fast adaptive optics for atmospheric compensation, fiber communications techniques adaptation to free-space, quantum cryptography, multiplexing both in time and wavelength, retromodulation techniques, etc. | In the US, JPL has been working for 30 years in both near-Earth and deep-space optical communications, although successive budget cuts have blocked several important demonstrations. In the early 2000s, Europe took advantage and first-positioned in near-Earth laser communication with the succesful Silex project (on board Artemis satellite), but no significant steps have been made since then. Nevertheless, in 2009, ESA included optical communications in space within its European Strategy of Non-dependence technologies.<br><br>Europe needs new research lines in order to become the reference in space technologies. Although the rest of space agencies are taking their first steps in free-space optical communications, there is not a clear commitment to this research line, because of the drawbacks of being a new technology and the difficulties of the tasks to be reached. This is an opportunity to lead this research.<br><br>Free-space laser communications is a technology with simple basic physical principles, easy to understand for the people, and with visual clear results and impact prospect in the society. For example, fast transmission ensures high quality live broadcast of space missions throughout the world. Past experiences from space research impact on humankind are enough to motivate the efforts in this new challenge. |
| German Research Center for Artificial Intelligence (DFKI) GmbH- Robotics Innovation Center Bremen | Dr. Thomas Vögele | Robust autonomous robots for space exploration | Research should be directed towards developing robotic systems that support human space flight and planetary exploration (e.g. assistive robots for operation in and outside of space-craft or on planetary surfaces) as well as un-manned space missions (e.g. to prepare for human space mission or to perform robotic space missions). Research topics to be addressed include<br>Robust robot behaviour at different levels of autonomy<br>Autonomous manipulation and new concepts for telemanipulation<br>Collaborative multi-robot systems<br>Innovative locomotion principles for planetary exploration robots<br>Modular and re-configurable robotic systems for planetary exploration and settlement<br>Control architectures for secure autonomous operations<br>- Sustainable energy concepts (e.g. energy harvesting) | Europe has strong expertise in academic research on autonomous robotics, but only a small industrial basis that is able and willing to produce such systems. This is true not only in the area of space robotics, but also in other application areas, most notably subsea robotics and, to a lesser extent, also security robotics. All three areas, however, are similar with respect to the principal requirements on robots, and all three areas have a high economic potential. In particular subsea robotics is crucial for the future exploitation of marine resources (oil/gas, minerals etc.) and environmental exploration and monitoring of fragile marine environments (e.g. Arctic Ocean). |

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| INSTITUTO DE ASTROFISICA DE CANARIAS | Jesús Burgos Martin | **A. Synergies between ground-based telescopes and space missions**<br>**B. Data exploitation and analysis of ESA science and exploration mission. Astrophysics and Astronomy.**<br>**C. Novel instrumentation for space mission and astrophysics** | A. SYNERGIES BETWEEN GROUND-BASED TELESCOPES AND SPACE MISSIONS<br>Space missions for astrophysics have the advantage, among others, to allow the observation of the Universe in wavelengths not accessible from Earth due to our atmosphere. They offer, in this important sense, clear advantages in comparison with ground-based telescopes. However, these last ones also count on other valuable advantages. The complementarities between both infrastructures for the study and understanding of the Universe, and the enormous possibilities offered by the co-ordinated and combined analysis of data gathered with both types of scientific facilities, means a remarkable asset for the European scientific community involved. Our astrophysicists have access to first-class space missions (ESA) and first-class ground-based telescopes (ESO); further synergies between these types of instruments for European astrophysical research deserve to be further explored and supported. FP8-Space can be the trans-national framework, in co-ordination with ESA and other national agencies, to support a set of research projects for astrophysics focused on the joint exploitation and analysis of data obtained with space missions and ground-based telescopes. These telescopes installed on Earth have, normally, a longer live expectancy and can overlap several space missions for similar research objectives, allowing for instance a baseline of data and coherent calibration procedures of interest for the costly space technologies. From the technological point of view, and well related with the expected development of the European space industry, ground-based telescopes are a very valuable test-bed for some specific technologies of interest for space missions. There are many examples supporting this idea; RTD projects aimed to exploit in a better way these capacities would be very welcome. Moreover, current campaigns of international relevance and carried out from ground-based facilities (some of them already supported by ESA), like the study of the Space Weather, identification of Space Debris, and the study of the long-term Global Climate Change, find, among others, very interesting links with some space missions and data. Financial support in these particular issues, under FP8-Space, could be of great interest for EU research teams. Supporting specific actions in favour of exploiting these synergies between ground- and space-based infrastructures for astrophysical research will have also a very positive impact in our society (outreach activities), since they could help people to understand why both technologies are complementary and why they need to be supported.<br>B. DATA EXPLOITATION AND ANALYSIS OF ESA SCIENCE AND EXPLORATION MISSION. Astrophysics and Astronomy. FP8-Space could provide more financial support for the exploitation and analysis of ESA science and exploration missions for astrophysics. Until now, this support is mainly provided by the National Governments through the corresponding programmes supporting research and technology in their countries. Financial support from ESA for conducting research with the data obtained with space missions is not available in this sense. Then, majority of research teams have to apply for these funds within their national borders, but this is not the most suitable framework to provide trans-national support. In this sense, the auspices and support from the European Commission, through the FP8-Space, could be the natural way to do it.<br>C. NOVEL INSTRUMENTATION FOR SPACE MISSIONS<br>Development and construction of instrumentation for space missions is very costly, and ESA, together with the national agencies, have demonstrated to be the appropriate trans-national framework to support this industrial activity. However, some support under the umbrella of FP8-Space to carry out conceptual and preliminary designs of novel instrumentation could be very helpful for EU research teams and companies. | Actions B and C, as aforementioned, would mean a natural continuity from FP7-Space. However, in our opinion, more financial support from the European Commission in these particular topics would be necessary to effectively cause the desirable effect over the research centres and industrial companies involved (jobs, training, public outreach, etc)<br><br>Concerning Action A (synergies between ground-based telescope and space missions), Europe is investing huge amounts of funds to build the most-advanced facilities on Earth for astrophysical research (E-ELT, SKA, EST, CTA, etc), and the most efficient and co-ordinated exploitation of these facilities, together with the also very costly space missions (HERSCHEL, PLANCK, etc), should be a must. This is the bet way to optimise the use of public funds, in terms of jobs, economic growth, and social welfare in general. |

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| INTA – Instituto Nacional de Técnica Aeroespacial | Héctor Guerrero | Reducing the European dependence on critical technologies by facilitating the ready access to the Space for in orbit testing of components and in-orbit demonstration of brand-new and disruptive technologies | The successful access to Space is usually related to the use of critical components and technologies. The TRL – Technology Readiness Level – associate a level of maturity of every part, element and system candidate for Space. The last stages 8-9 (up to actual system 'flight proven' through successful mission operations) are hard to achieve, even for “mature” technologies. Always is needed a flight opportunity. And what came first, the chicken or the egg?At present, at European level there is a great lack of opportunities to got o Space. There are not many technological Missions available (if any!!!) with real possibilities to insert “breakthrough ideas”. The European Space Community has many actors working on reducing the gap on critical technologies. These are demanding for more efficient strategies to reach Space. This Community needs frequent and cheap platforms and missions for in-orbit demonstrations and test-beds. ESA initiatives in this sense are expensive, not agile, and widely separated in time. The reason is clear: ESA can not put its ‘stamp’ in any risky scenario, due to fear of having a failure. And that’s normal !!There is a huge demand in going to Space to prove concepts and innovations. Official and traditional ways are quite “tight”. A more dynamic scheme needs to be promoted - jeopardized - from European Frame Programs. Is the right way to mobilizing private initiatives? National Agencies?If we want not to be dependant on critical technologies, we need to short the way in some ways to have an easy access to Space for technology and testing. For example, testbed dedicated platforms (20-25 kg), with launch to Space from non-conventional launchers (Aircraft based launch systems?) need to be developed. | Achieving the quick and cheap access to Space is critical for European innovation. Nowadays, many of the innovations in the Space field are still originated in European Space research Centres, SME’s, and Universities. This huge potential is lost because the very reduced offer in technological missions. These never gain a test opportunity to be demonstrated in orbit, and their industrialization advantages are lost with time in form of academic publications, proceedings, etc. The original interest progressively decreases, and patents are not finally fulfilled. Our non-European competitors have a large portfolio of ideas made in Europe for Space almost by free. If they are more agile and systematic in taking profit (by offering flight opportunities) they will gain with our old advantages. To achieve the commercial niche of Europe as a powerful area with technologies for in-orbit testing will be of great importance for some of the futures Space actors: start-ups and spin-offs, brand-new SME’s, young students and engineers. The expected activity around a future network of companies related to in-orbit testing and demonstration is presumed as of major importance. Our presence in Space needs to be ‘fresh’ and frequent. European citizens need to generate the idea that we are ready for Space. We need to be compliant with the statement: “Going to Space is not enough any longer; We must Stay in Space”. |

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| ISIS – Innovative Solutions In space; Delft University of Technology; University of Twente | Jeroen Rotteveel, Chris Verhoeven., Mark Bentum | Nano-satellite swarms: technology development, hardware development and industrial utilization in deployment of scientific and commercial swarm missions. The main research challenge is the development of hardware and software to enable the implementation of a swarm of nano-satellites for both scientific and commercial missions. | It has become quite clear that nano-satellites are very different from standard satellites that are now in commercial and scientific use (ref on the origin…). Given the trends towards miniaturisation, distributed intelligence and advanced networking technologies, larger numbers of smaller satellites working together towards a common goal. Bio-inspired research indicates that the there is a niche for missions based on nano-satellites with insect-like behaviour operated in swarms. Two high potential swarm missions have already been defined. The scientific mission is the OLFAR low frequency radio telescope base on nano-satellites in moon orbit. Other, more operational oriented applications are nano-satellites that can form a reliable and omnipresent surveillance and monitoring network in low earth orbit that will improve the safety and situational awareness concerning ships (using AIS), aircraft (using ADS-B) and other forms of asset tracking (using dedicated systems), especially in remote areas.<br><br>To address this research challenge the following key research topics need to be addressed:<br>•The design an implementation of a highly potential micro-propulsion system that enables the orbit change , orbit control and further manoeuvrability needed to enable swarm based missions, which includes reliable end-of-life solutions to mitigate potential increase of orbital debris.<br>•The design and implementation of the hardware and software needed for swarm control.<br>•The design and implementation of a miniaturized (deep)space navigation system. Using highly miniaturised star trackers, or novel technologies such as pulsar navigation.<br>•The formulation of a systems engineering theory that is tailor made for efficient and reliable design of nano-satellites and nano-satellite swarms, based on COTS technology.<br>•The development of satellite system set-ups that enable efficient design re-use (like plug and play), focussing on universal spacecraft bus elements in order to drive down cost for such systems.<br>•The development of efficient and cost effective (mass) production techniques to enable commercial use also for new players in the space market.<br>•The exploitation of sustainable, affordable access to space for small scale research missions as initiated by the EC under the FP7 space topic. | Nano-satellite technology will enable new commercial products and services that rely on a reliable but very cost-effective and easy to deploy space segment. The European high-tech industry focussed on miniaturization and the application of main stream IC technology for commercial terrestrial applications (like automotive, telecom) will be able to enter the space market and develop new business cases, without ITAR restrictions. The choice of technology also dramatically eases the spin-out of research results to terrestrial applications with a large market. Nano-satellites bring space systems within reach of SMEs and young researchers and businessmen.<br><br>Nano-satellite technology development, construction and operation will stimulate the growth of a young, highly innovative high-tech industry with an impact that will go far beyond space industry itself. It will give a large contribution to the competitive power of the European high tech industry and the possibility to obtain a leading role in the commercial use of highly miniaturized space systems.<br><br>Europe took its first steps into supporting this novel niche in the space sector in the FP7 Space call for 2011, focussing on one of the key bottlenecks: access to space. With such a bottleneck removed, partly through the support of the EC, this opens up opportunities to establish international collaborative projects that can use this new access to space for groundbreaking scientific and technological research. |
| IUSS- PAVIA | Giovanni F. Bignami | Europe and the Exploration of Space. We propose a role for the EU in space exploration and suggest a worldwide, authoritative approach for both robotic and human exploration | With European robotic exploration safely in the hands of the European Space Agency, as well as of (a few) National Agencies, the role of the EU, and in particular of FP8, would be that of thinking in broader terms, and to develop a vision for future human exploration. Such a visionary plan, to be developed specifically in the context of FP8, should of course start from an assessment of the world situation, especially with respect to the US plans. COSPAR is ideally placed to act as an “ambassador”, or opinion maker, between “space superpowers”, like US, Europe, Russia, China, India, Japan, etc. COSPAR is the only body in the world where all of the above are represented.<br>Today, US plans are still very much in the vague, with definite difficulties related to new forms of propulsion but also due to a lack of a well-defined target.<br>Europe could join forces with the world space superpowers, and be a protagonist, by choosing well a few selected research topics. The definition of such European topics is the main thrust of the work to be addressed in the FP8 context. Examples could include innovative propulsion, including nuclear one, something on which a lot of work needs to be done worldwide, but on which Europe can become competitive with the rest of the world. More examples: access to space, since Europe already has Kourou at low latitude, ideal for accessing the ecliptic plane and possibly playing a role in a new orbital world spaceport, plans and prototypes of re-entry, transport and habitation vehicles and modules, and much more. | Europe cannot stay out of space if it wants (as it does) become a knowledge-based, high-technology world power. Within space, the challenge of preparing a global vision for exploration is a high-priority one. The moment is ripe: the US are still considering options and are certainly open to collaboration proposals. The rest of the world is also looking at us. We in Europe are enjoying an industrial environment particularly strong and with differentiated capabilities, with a notable peak in space propulsion. Nuclear energy exploitation, for example, in the context of a space exploration plan would provide the necessary R&D stimulus in the coming years. In more general terms, space research is known by now to be one of the best investment multipliers for public funds, in terms of jobs and technology development. But the real essential contribution for Europe would be the intellectual development for a new generation of European scientists and engineers. Here again, COSPAR could help, by suggesting role models from other space powers, by favouring exchanges of experience and know-how and by providing a stimulating, world-wide framework of ideas. Within such a framework, one hopes, young Europeans will feel challenged to rise to the top. |

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| Jacobs University, Bremen, Germany | Peter Baumann | Next-generation open on-board Earth Observation data interfaces | Currently EO instruments form the beginning of a processing pipeline which downlinks L0 and finds its end, such as L3/L4, much later, at the ground control data segment or with some data service provider. This relatively passive role of the EO sensor makes it quite inflexible and difficult to access for all but some privileged data centers.<br>A different idea is to put the complete processing pipeline on board the satellite so that, e.g., L4 products, seamless mosaics, and even timeseries can be served by downlink.<br>Enabling open standards for such value-added on-board services are provided by the Open Geospatial Consortium (OGC, www.opengeospatial.org) with the Web Coverage Service (WCS) 2.0 suite. WCS-conformant interfaces can provide a sufficiently high-level service abstraction allowing for simple, yet flexible access. This includes a broad range of service levels: On the low end, this is the WCS core which offers a simple access and spatio-temporal subsetting functionality. On the high end, this is the Web Coverage Processing Service (WCPS) which offers "XQuery for multi-dimensional raster data", that is: an open-ended query language operating on pixel level. Examples for derived products which can be generated ad-hoc include difference indexes like the NDVI, histograms and other summary data, even a Discrete Fourier Transform. End-user interfaces would hide the language from the users by offering intuitive point-and-click interfaces which internally generate the requests.<br>NASA has started experimenting on this and plans on offering WCPS on board of Hispiri; a demo video is available on http://kahlua.eecs.jacobs-university.de/~earthlook/videos/index.php.<br>Interactive demos on www.earthlook.org show the variability of WCPS, based on the rasdaman (www.rasdaman.org) reference implementation. | 1- massively improved access to EO data; through suitable end-user interfaces hiding the query language under an intuitive point-and-click interface, even school classes may request processed data from a satellite ("the vegetation index of our region during the last 10 overpasses"). This opens op fascinating perspectives for both hobby researchers and experts. Of course, access regulations and quota would apply.<br>2- substantial gains in bandwidth efficiency. For example, compare downloading a 250-band scene for deriving the NDVI with a download of (i) only one band, the NDVI, and (ii) only over the area of interest.<br>3- flexible, fast response to manifold, diverging needs; in particular disaster mitigation can benefit immensely from that (think about local forces having devices which directly request information from the satellite within seconds, rather than going through days of download and processing by some data center).<br>4- a European technology boost by establishing efficient service technology combining query optimization, smart caching, use of advanced hardware, etc. |
| Joanneum Research, Institute for Information and Communication Technologies | Gerhard Paar | Spatio-Temporal Integration of Different Scientific Cues on Planetary Surfaces and the Moon | During the last few decades, space probes have collected huge sets of scientific data from Planetary surfaces, their interior and atmospheres. For the understanding of geologic, meteorological, geophysical, geotechnical and exobiological processes the exploitation of different cues from various sensors is inevitable. In specific cases a combination of images in different scales, spectroscopy, morphology, chemical and biochemical investigations as well as active & passive radiance (laser, radar), gravity and particle impact applied either remotely, tactile or by investigating or even returning samples to Earth, has revealed outstanding scientific results about the nature of the Solar system.<br>However, no global attempt has ever been made to put such measurements – in most cases collected by different teams from different nations – into a unique spatial and temporal context. Data are stored in archives (such as NASA pds) giving access to the individual data sets, in most cases allowing a trace-back to the sensors used, and the location and time of measurement – but not their cross references to each other.<br>The main objective of the Context Integration mentioned here is to generate a spatio-temporal map of all available scientific data collected on Planetary surfaces so far and in future, allowing their access by means of up-to-date visualization & presentation (e.g. a 3D GIS & attached data base to search for scientific measurements of all scales in a specific region or time frame). In this sense, already existing interdisciplinary experiments will be complemented by the outstanding ability to add "serendipitous" science, i.e. to detect interconnections between the scientific data hitherto hidden, and thus revealing new signatures from such combinations.<br>The initiative would include activities in particular in the following areas:<br>-Map building making use of image data in all scales, from Orbit to surface microscopy<br>-Collection / archiving / description / presentation of scientific data in a unified manner<br>-Web-based technology for interactive sharing of interpretations based on the science map<br>-Systematic search (data mining) of inter-relationships between spatially and temporally related data to reveal new, unexpected knowledge<br>-Association of imaging with metadata such as in-situ analysis, physical properties, etc. | Systems like Google Mars ® and Google Moon ®, by means of the most evident use of images, show that the common understanding of spatio-temporal relationships considerably raises the level of possible interpretation of such data. Having a "Scientific Information System" that contains all scientific data of all available nature would allow different interpretations and in such way add one level of exploitation to existing scientific planetary data collections. The Planetary Science Community in Europe is strong and well organized, in this sense Europe can act as bridge between groups of scientists all over the world.<br>It needs to be mentioned that co-operation with international space research & exploration institutions (e.g. particularly NASA-JPL and other government-oriented assets) must be sustainably facilitated throughout FP8 in order to enable such endeavours, particularly on contractual level. |

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| Keldysh Research Center | A.S.Koroteev | High Efficiency Space Transportation System based on Nuclear Power and Propulsion - SPACE NUCLEAR POWER AND PROPULSION (SNP&P). | TODAY:<br>1.Only solar power is used in space power and propulsion systems;<br>2. Continuous growth of power supply systems capacity (up to 30 kW on geostationary communication spacecrafts) and power to weight ratio of spacecrafts;<br>3. Expansion of EP application, including the realization of transfer operations<br>4. Power supply of modern spacecrafts (1– 5 kW per 1 ton of spacecraft weight) is insufficient for advanced space tasks.<br>TOMORROW:<br>1.Realization of deep-space manned missions (for example to Mars);<br>2.Development of a system for Earth protection from asteroid and comet threats;<br>3.Space debris deorbiting;<br>4. Development of space manufacturing technologies.<br>It can be done just on the basis of application of nuclear power in space both for power and thrust generation<br>MAIN ADVANTAGES OF SNP&P<br>1.Power production is independent from orbit highting, spacecraft orientation and distance from the Sun;<br>2.High-power systems are feasible;<br>3.Essential advantages as compared with solar energy systems of high power:<br>- mass-and-dimensions and dynamic characteristics,<br>- cost characteristics,<br>- radiation resistance in exploitation.<br>4. Opportunity to use high-efficient plasma thrusters.<br>BASIC CONCEPT OF NPPS.<br>The gaseous coolant (a mixture of helium and xenon) circulates in a closed circuit. Reactor provides heating; the turbine drives compressor and the electric generator to produce electricity for electric propulsion. Heat-exchanger-recuperator is used to increase the cycle efficiency. Releasing of "redundant" heat is performed by means of the cooler-radiator<br>POTENCIAL AREAS FOR COOPERATION RUSSIA WITH EUROPEAN RESEARCH AND INDUSTRY:<br>1.High-power/high-Isp/high lifetime plasma propulsion;<br>2.High-temperature turbines with high rotation speed;<br>3.High power space cooling systems;<br>4.Control systems with long lifetime at the conditions of high neutron flux;<br>5. Application of SNP&P for space transportation. | Expected impact:<br>3.1.Creation of new jobs;<br>3.2. Inspiration of young Europeans to be involved in space science and industry. |
| Lessius University of Applied Science – KU Leuven | Ing. Dirk Van Merode | The importance of educational institutes in the design of life support systems for space missions, and other biological space experiments. | As long duration manned missions are considered in the near future a lot of experiments on life support systems and space environment will be necessary. On the other hand experimenting in manned missions and traditionally large satellites have become virtually impossible due to capacity of existing systems (no more space shuttle flights, ISS experiments too expensive and scarce). This calls for a new approach. Pico and small satellites could fill the gap for doing necessary experiments on life support systems. Research on the physiological and metabolic properties of in zero gravity has its application in the field of prolonged manned space missions. Bacteria can be used for waste recycling and resource recuperation, but can also be hazardous when travelling along in confined spaces, such as the ISS or because of corrosive properties.<br>To investigate the change of conduct due to microgravity and cosmic radiation a lot of tests should be done with a lot of different types of biological loads. This is often not possible to do in the ISS, because waiting lines are long and getting tests on a mission is difficult.<br>Pico-satellites (CubeSats) can be a solution to do more frequent and cost-effective research, if tests can be automated, controlled and monitored from earth. Defining a proper biochemical experiment, is a challenge, as for now recovery of reaction products is not feasible.<br>As the possibilities to use CubeSats in research projects increase, due to ample initiatives to provide easy access and multi-orbiting of pico-satellites, research and educational institutes can take an important role in vital biological research and in spread of this innovative know-how. | European countries are challenged with a decreasing amount of young people who will engage in technological studies. The possible participation in high tech studies involving space – the final frontier – will be highly motivating. Combining the strength of existing organisations – like ESA – and the larger university community, will boost the knowledge input and technical know-how of society. More and more educational institutes are looking for means to access space to expose their expertise. It is therefore advisable to use a payload with high potential for future space applications. This will not only increase access for orbital experiments, but also will attract more students keen on working in space research and other high-innovative sectors. This in turn augments the availability of high-educated technical profiles, motor of today's economy.<br>Research institutes are very keen on augmenting innovative knowledge in the biological, electronic and mechanical aspects of (space) design. The design of radiation hard, fail save and redundant space systems, with suitable mechanical strength and material properties, is a big challenge and these challenges in turn are important for local SME's who want to produce applications or work in other critical market segments, such as medical industry, petrochemical industry and aviation. |

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| Logica | Pat Norris | identification, characterisation and orbit determination of space debrisb., b. removal of large space debris objects | a. radar and optical data exists so the priority is research into robust (>TRL7) algorithmic and IT technologies to process the data without compromising security<br>b. concepts for grappling spent upper stages and dead satellites need to be taken from TRL3 to TRL7 | Europe's space industry employs >60,000 people directly, >250,000 indirectly and is growing steadily. Space debris in the region below 1,000 km altitude is reaching the point of self-generated growth as debris pieces smash into each other generating more debris. Analysis has shown that removal of half a dozen large objects from the debris population per year will reduce the population to below this critical mark. Detailed mapping of the debris population is necessary to detect and prevent collisions. The future of a large part of Europe and the world's space activities depends on this. |
| Max-Planck-Institut für Biogeochemie | Prof. Dr. Martin Heimann | Quantification of regional greenhouse gas budgets from multiple space based and in situ observations for the establishment of an Integrated Global Carbon Observing system within GEOSS. | Several next-generation space based greenhouse gas remote sensing missions recently launched or planned for the near-term future (a.o. GOSAT, OCO-2, CARBOSAT) are expected to significantly enhance our observation window for the monitoring and regional quantification of key greenhouse gases, such as carbon dioxide (CO2) and methane (CH4). The global coverage of these systems will allow new insights into the global cycles of these gases, and are expected to significantly help us understand the complex source and sink processes, in particular in hot-spot areas that are difficult to cover with traditional in situ measurements (e.g. permafrost areas, tropical rainforests, southern ocean etc.). Also, space-based observations in principle provide a unique opportunity to independently verify national commitments for greenhouse gas mitigation and support thus the UNFCC.<br>The practical use of these new data streams, however, faces two critical challenges:<br>(1) The space-based measurements must be validated and calibrated against the in situ network. The long lifetime of CO2 and CH4 imply very small relevant atmospheric concentration gradients, which need to be detected with a high accuracy (1ppm for CO2, <20ppb for CH4).<br>(2) Space based observations record only column integrated concentrations of the greenhouse gases and atmospheric modeling systems are needed to derive quantitatively the spatial and temporal patterns of the sources and sinks.<br>Substantial research needs in order to fully exploit these new data streams have been identified by the GEO carbon community of practice in the GEO carbon strategy document (http://www.earthobservations.org/documents/sbas/cl/201006_geo_carbon_strategy_report.pdf). This includes the development of novel ground-based and in situ validation techniques, the complementation of the in situ network in critical, under sampled regions. It also necessitates the development and validation of next generation modeling systems for greenhouse gases in order to integrate in a consistent way the multitude of space-based and in situ information. | The global carbon cycle determines the amount of carbon dioxide and methane that accumulates in the atmosphere, increasing the Earth's greenhouse effect. It is therefore a key component of the global climate system. The carbon cycle also responds to climate change, and understanding the ability of the carbon cycle to continue to act as a partial sink of fossil fuel emissions into the future will be a vital factor in determining the "allowable" fossil fuel emissions, while keeping concentration below certain levels. Current uncertainties on the space-time distribution of CO2 and CH4 fluxes are still very large. For well-informed policy action aiming to curve down the future increase of CO2 and CH4, these uncertainties must be reduced, by establishing a consistent and reliable Integrated Global Carbon Observing system (IGCO). Such a system is one of the key priorities of GEOSS, and clearly, Europe needs to contribute to this endeavour. |

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| MCTES | João Romana | Earth Watching for Emergency Support Mission (EARTHWATCH) | Currently there are several satellite missions dedicated to EO and integrated on GMES. Almost all missions, especially those for High Resolution Imagery (HR) and SAR, are on Sun Synchronous Low Earth Polar Orbits (LEO) at average 700 km altitude. The LEO is a good compromise between cost and EO capability for the current state-of-the-art technology. For mapping events that are not real time critical (such as environmental mapping, risk mapping analysis, cartography) LEO EO sun synchronous satellites are adequate, as they allow one image a day or week per spot.<br>Yet, for tracking events that are real time critical, requiring multiple images and/or videos during the day and night (typical of emergency scenarios or security issues) there is no solution available or foreseen with GMES. LEO Satellites are not a convenient solution to follow these events as a 90 minutes orbit is necessary to be back to the same spot and energy needs to be spent to correct trajectory continuously. The convenient orbit geometry for EARTHWATCH satellites able to trace real time critical phenomena are Geostationary orbits, which are the case of Meteorological and Communication satellites.<br>EARTHWATCH is to continuously track (real time images or video) any event on Earth from a Geostationary point above, dynamically adapt spatial resolution (from the entire Earth disk zooming down to local), using different spectral windows and measuring atmosphere content (aerosols, particles, Chemical ) and ocean water level.<br>In terms of research and technology requirements, these new EARTHWATCH satellites may require new advanced CCD image sensors, new radar units, faster data transmission buses and new atmosphere sounding units.<br>While Sun synchronous satellites make easy use of reflected sunlight to grab Earth surface information during daytime, EARTHWATCH will have to overcome the scarcity of sunlight during night period and/or use different spectral windows. The extraordinary amount of data collected by such a system may also require new data transmission technologies. Atmosphere sounding units also require a new development to adapt current technology to new functionalities. The technological trends behind a new GMES family of EARTHWATCH missions, clearly justify a new R&D topic under FP8. | The “S” on GMES has been by far the component which has least benefited from FP7. The underlying concept of GMES evolved during FP7 and has finally materialised into a full package to be spin-off the FP research phase and enter a new GMES operational programme (2014 on). The GMES Operational Programme is based on a set infrastructures (5 Sentinel missions and many more independent missions) especially designed for “Global Monitoring of the Environment”. The planned GMES Sentinel and support missions are LEO polar orbiting sun synchronous missions allowing EO at many different ground resolutions (from 1 to 1000m pixel) and many different spectral windows (visible, non-visible, radar). It will thus be possible to access EO data on a daily basis over the same spot and at the same time of day. Although, this operational scenario brings in huge advantages in terms of Global Monitoring of the Environment for targeting events that have a daily, weekly or monthly periodicity, it will not cope with monitoring Emergency and Security events. Actually GMES missions neither are configured to do better than one shot a day on each spot, which means Emergency and Security operations will not be able to take any benefit of GMES for real-time support to combat Emergency and Security operations. Recent examples of natural disasters (volcano eruptions, tsunamis, floods, forest fires) that have strongly affected the society and economy of the World were and will be unable to get real-time support from GMES. Launching specific missions for a Continuous (24/24) Earth Watching Operation would overcome the handicap to cover the “S” in GMES in benefit of the citizen, clearly. |
| MEDES-IMPS | Audrey Berthier | Research, development and validation for advanced dual integrated countermeasures for space exploration and human public health on earth. | Up to now, none of the currently existing countermeasures has proved to be fully efficient to counteract all the impairments observed on the human body in weightlessness. Some of them however, like bone or muscle loss, are still major issues to solve in view of the future long duration missions. The effects of weightlessness on the human body can to some extent be compared to the effects of sedentarily lifestyle and of ageing, and research towards the development of new countermeasure can also strongly contribute to new insights for public health. For the development of new innovative integrated countermeasure, there is a need for additional integrated research to define the optimum stimuli for the intervention, the responding elements to these stimuli (at cellular, tissular and physiological level), the modulators of the responsiveness (genetic ones, age, gender, nutrition...) and the predictors of the responsiveness. Such research is needed to define optimised combinations of intervention measures and to define the safe ranges of intervention.<br><br>An example is to define the optimum mechanical loading to prevent musculoskeletal deterioration, to define the optimal levels of g stimuli to prevent the effects of weightlessness in space, and of sedentary lifestyle on earth. Several research have started to evaluate the effects of different types of mechanical stimulations reproducing optimum mechanical loading of daily life on earth. It is proposed to implement an integrated collaborative European project, gathering data from astronauts and from large cohorts with controlled mechanical loading, in order to define the optimal g stimulation to prevent bone and muscle loss for both space and terrestrial situations. This research could lead to the definition of new intervention measures including exercise regimens, rehabilitation programs. Such project would contribute to better prevent osteoporosis and sarcopenia and the frailty of persons at risks, elderly or bed ridden patients. | Integrating space research for human space exploration, when relevant, in a broader perspective will increase the return of investment and give more visibility of the space program to the European citizens.<br><br>Osteoporosis as well as sarcopenia are important public health problems which incidence is increasing with the ageing of the European population and the sedentarily lifestyle. The improvement of efficient countermeasures would have a huge economic and public health impact. Maintaining muscular function is also of prime importance for healthy ageing, to which space research could contribute.<br><br>The few economic studies which have been performed, as for instance the Herzfeld study “Measuring the returns to NASA Life Sciences Research and Development”show a return on investment of space research in life sciences for NASA. MEDES experience on cooperative projects performed within the human space exploration programme (spin off of ultrasound devices, telemedicine, bone quality device,..) also show this return of investment.<br><br>Research in human space exploration is also appealing and incentive to attract more students to scientific and technological careers. |

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| **MELiSSA: Closed Loop Life support System** | **Pr Max Mergeay** | **MELiSSA: Closed loop life support system.** | Future manned missions beyond Low Earth Orbit, will require a high mass of human metabolic consumables (e.g. oxygen, water, food), and appropriated environment for man activity. These two issues are very seriously challenged by the capabilities of current launchers, as well as the very high microbial and chemical risk due to the very reduced and tight volume of space vehicle. In other words, absolutely all waste have to be recycled and risks shall be very seriously handle. These closed loop requirements associated to a large number of cycles implies to completely reconsider the approach of waste recycling and consequently to:<br>- characterise recycling processes at a very high level of know-how,<br>- Model, predict and control a cascade of processes with intertwined flows,<br>- Detect, evaluate, and mitigate all risks,<br>- Consider human acceptance of recycled product,<br>- Avoid or drastically limit the use of any exogenous products, | This research is today totally in line with European desire of sustainability, and may lead to considerable spin-off for European community. A large number of fields investigate within MELiSSA project such as: - Micro-algae production, waste recycling, water recycling, microbial and chemical detection and removal, modelling. Have major interest in terrestrial industry (e.g. pharmacy, chemical industry, oil). Moreover the environment, ecology, toxicology, is totally in line with the interest of European citizen, including student and young scientists. |
| **Microgravity Research Center, University of Brussels** | **Valentina Shevtsova** | **I fully support the ideas outlined in the presentation by Dr.ing. Jack J.W.A. van Loon Microgravity related research within Europe."** | As a researcher, I have already conducted the scientific experiment SODI-IVIDIL on the ISS in 2009-2010 in the frame ESA -ELIPS program. For the moment I am involved in preparation of two other experiments on the ISS: JEREMI (with JAXA) and DCMIX (in frame of ESA program).<br><br>To receive the best return from the experiments on the ISS they should be well prepared and tested (when possible) on the ground. Presently, ESA may provide flight opportunity but the budget for the experiments preparation could be received from the National Funding or from other sources.<br><br>However, National Funding not always can support adequately the researchers and "other" sources are not very often interested in microgravity research. For European researchers, to be competitive on the World scale and to use flight opportunity in the smartest way, it would be extremely beneficial to receive financial support via EU. | The order of priority is: inspiration of young Europeans, jobs, energy, environment, |
| **Ministry of Transport and Communications** | **Mikko Strahlendorff** | **Remote Sensing and in situ observation instruments for Earth Observation applications should generally be included in the Space theme.** | The technology in remote sensing (=active or passive sensing of the electromagnetic radiation spectrum) is most of the times the same on satellite platforms as for airborne or even some land based instruments. In situ sensing on the other hand is the essential ground truth to make remote sensing information useful. Combining all measurements is the real deal to solving environmental and security knowledge challenges of today. | It makes little sense to only research remote sensing sensors for the purpose of space application. They have a better potential for application under the clouds and should be brought to the broadest possible innovation and application impact by being all included. This would also include them in GMES to enable the most effective Earth Observation possible. The same applies for in situ equipment, which is all a part of solving the same questions for society.<br><br>With the Innovation Union the EU wants to pool more cleverly to be more resource efficient. Here is where is can be done! |

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| National Aerospace Laboratory NLR | BJP van der Peet | Space Infrastructure for UAS operations. | For Unmanned Aircraft Systems (UAS) operating beyond line of sight of the ground station, satellite infrastructure plays an essential role.<br>This applies for traffic management/collision avoidance, communications, autonomous operations and environmental conditions.<br>During past years many countries started to address the challenges of integrating UAS in Non-Segregated airspace. Within ESA, EDA, NATO, Eurocontrol, EASA, European Commission, Eurocae and the Member States various research is being and has been conducted on elements such an integration UAS. These activities focus on architectures, concepts and simulation of SatCom enabled ATM integration (like the ESA IRIS programme), wide bandwidth payload data links or autonomous operations using EGNOS/Galileo. For military operations in segregated airspace, such integration is more or less becoming routine. However, for operations in non-segregated airspace, this is not the case, although highly required. Large unmanned aircraft will most likely fly in controlled airspace first, where instrument flight rules determine the flight profile and manoeuvring. To short-circuit the see and avoid issue, the air traffic controller is the eye of the aircraft through his radar picture. For these operations, other regulations (e.g. safety, airworthiness), rules / procedure (e.g. separation) and conditions to ATC and the UAS Operator will apply. Definition of minimum safety requirements and corresponding certification standards is an ongoing process. The outcome will have impact on the required performance (bandwidth, reliability, availability) of the primary communication and navigation systems.<br>The goal will be to integrate the different elements in a fully integrated approach as well from a technical point of view as from a procedural/regulations point of view to demonstrate and validate the proposed concepts. | Applications that require such routine UAS operations in non-segregated airspace (Transit and Ops Area) are land and maritime based. For e.g. they include border and maritime security surveillance, infrastructure monitoring and training (both civil and military operators) and on longer term, transportation. These applications are cross bordered and therefore require a European solution to open a European market. In line with the approach followed in the FP7 Transport and Security programs , it is recommended to build upon work done on sub-system / capability level, by conducting integration and demonstration projects with satellites. This a very powerful mechanism to align European and national research activities and to direct towards an operational capability. Such a coordinated effort helps to strengthen the European industrial base by setting standards and thus opening a European market for (space enabled) UAS manufacturers and service providers. |
| National Space Institute, Technical University of Denmark | Eigil Friis-Christensen | Exploring results from European space missions | Europe has a vigorous space programme that has provided a wealth of new scientific data in particular within the ESA Science Programme and the Earth Observation Programme. The scientific level and the novelty of the observations from the European missions can easily match those of the US missions but according to the rules of ESA, the support for that part is left to the individual ESA member states meaning a less coordinated and dedicated effort. In addition, and in particular obvious in the Earth Observation Programme, there is both a need and an opportunity to provide a framework for research based on a combination of observations from various missions and supplementary ground-based and airborne missions. Just one example of such an opportunity is the scientific understanding of the changes of the cryosphere – i.e. the melting of the sea-ice and ice caps – which has been monitored uniquely in the last years with new satellite missions – IceSat, GRACE and now the ESA CryoSat mission. Ground-based satellite-supported techniques such as GPS/Galileo and airborne lidar/radar missions supplement these missions. With all the different programs, results are still highly ambiguous and not sufficiently accurate. There is an urgent need to unify results of changes from the different types of monitoring – radar, laser, gravity and land uplift, addressing such issues as penetration of radar signals in snow (critical for CryoSat), ice sheet firn compaction (critical for IceSat), merging missions for higher resolution (critical fro GRACE), and understanding the GIA process in glaciated regions (critical for GRACE and uplift).Current estimate of Greenland and Antarctica mass loss changes disagree by up to 100% in recent papers, so there is an urgent need to narrow down the estimate, especially to improve models of future sea-level rise. | A major difference between the European ESA Space Programme and the US NASA programme lies in the fact that NASA supports the scientific exploitation of its mission while ESA has left this part of the programme to the ESA member states. This results in a situation where ESA space missions are not exploited at a level corresponding to the capability in the European scientific community. Consequently, the exploitation is in many cases limited to the ESA member countries that have National Agencies supporting the science. The European Space Science Committee (ESSC) within the ESF has expressed concern regarding the availability of young researchers in the development of the scientific and technological capability in Europe. Space missions comprise one of the areas that may inspire young Europeans to start an education in science and technology but the current lack of dedicated funding means that talented young people either deselect a scientific career or decides to be employed in US. A more dedicated effort regarding the exploitation of the available space data may have great socio-economic importance to Europe. New initiatives for development of supplementary airborne and space sensors could generate significant jobs in SME enterprises. |

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| Network for Maritime Applications, Rostock, Germany | Silvia Westland | Maritime Safety and Security<br>Maritime applications in navigation and logistics; high precise and reliable satellite-based positioning in realtime in combination with geo-data | 1-information on time and position will be common data<br>2-different user groups within the intermodal transport process have diverse requirements concerning accuracy and need for exchanging information between users and systems<br>3-this requires an overview on existing systems, want are the advantages and disadvantages<br>4-a future development to interoperability is needed, e.g. connecting to indoor tracking and tracing<br>5-end user wants a single point of contact for his demand<br>6-applications should have high update rates and should be independently from the used media, display modes should vary (zoom in and out)<br>7-optimizing the harbour processes by connecting moving persons and objects like ships, vehicles and cargo<br>8-user friendliness by visualization and integration of web applications<br>9-this requires support to regional SMEs with international aspects, national advisory by institutions to write good proposals, enhance international cooperations for information exchange<br>10-most important is the dependence on reliable and realtime data for the research and development institution<br>11-national and international certification and standardization will secure and harmonize the market | 1-enhance maritime awareness<br>2-integrating rising traffic volume worldwide<br>3-current demand for increasing safety<br>4-using contemporary legislations to increase the protection of the environment<br>5-maritime sector is an important part of education and training and a job monitor |
| ONERA | DONATH Thérèse | Security of Space Assets" needs "Joint Space Situational Awareness. | As Space is a global issue, security in space has to be too. The example of space debris illustrates this assertion: A catastrophic collision between one operational asset and one debris generates hundreds of new debris in the vicinity of an operational orbit which threaten other operational assets. The higher is the orbit energy, the longer is the duration of threat for this orbit.<br><br>To improve safety of space assets with respect to man-made environment, some possible means are:<br>1. Mitigation guidelines to lower the number of inactive satellites in operational orbits,<br>2. Space Situational Awareness (SSA) to provide a picture of trackable debris and space weather predictions,<br>3. New S/C design to improve protection against untrackable debris collisions,<br>4. Active debris removal within most populated operational orbits.<br><br>All these means are currently and separately being worked out. The specific research which needs to be performed is to evaluate the interest for SSA of the contribution of in-situ measurements made by operational S/C as the communication of their manoeuvres by operators. The fusion of all this information (from SSA and in-situ sensors, manoeuvres) will provide a joint vision from many space actors: Space agencies (via the SSA sensors), manufacturers (via the design of new platforms equipped with on-board debris and environment monitors), operators (via the communication of in-situ measurements and manoeuvres) and insurers (via the obligation made to the operators). The related data fusion is really a technical challenge since the volume of data may be very important and the association of data to the correct space object (i.e. already detected) in order to maintain the knowledge over time is not a trivial task.<br>Correlatively, the improvement of orbital parameters knowledge for operational S/C and their unrestricted dissemination may endanger them from intentional threats. Work on data policy has to be held in parallel to limit this new exposure. | Space assets are taking more and more importance in the life of European population, in the European economy and the European policy of security and defence. Then, security of space assets impacts directly on the every day life of European citizens.<br><br>As space is a global issue, it is also essential that this research be conducted at European level because it is mandatory to acquire a joint vision between all European space actors: space agencies, defence authorities, operators, manufacturers and insurers.<br><br>The outcomes of this research could change deeply the minds of European space actors since every actor would be partly in charge of its own security and of the security of the others. Such joint vision could give an excellent basis for European cooperation and negotiation with other main space fairing Nations such as US, Russia and China. |

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| ONERA | Frédéric Sourgen | Enhancement of hypersonic hyperenthalpic hot-shot facilities. | The hypersonic hyperenthalpic wind tunnel F4 uses an electrical arc in a chamber to provide high pressure and high enthalpy values (up to 800 bar and 20 MJ/kg for air or CO2 test gases) allowing atmospheric re-entry conditions. Although the value of the reservoir pressure is accurately measured, as well as the electrical power, the energy in the chamber cannot be experimentally assessed so far due to dramatic thermal conditions in the chamber. Only “a posteriori” estimation of the effective energy in the expanded gas is affordable and expressed by a simple correlation. A major enhancement to master hyperenthalpic flows in hypersonic hot shot facilities would be to predict and reproduce accurately the realistic energetic behaviour of the plasma gas confined in the chamber during the arc heating process. Accurate knowledge of physical phenomena occurring in the arc chamber is fundamental to characterize the actual hypersonic flow that will encounter vehicle models and to apply accurately the ground-to-flight extrapolation based on the validation of sophisticated numerical tools. This involves the physical modelling of a non-stationary, high pressure plasma coupled to a radiative non-equilibrium gas and thermal exchanging liner walls made of C-SiC in a 10 liters chamber. So far, none realistic computation or analysis of the heated plasma flow has been yet performed. Improvement of such facility needs to apply plasma simulation tools to these specific operating conditions assuming considerable electrical and pressure measured values.<br>The work breakdown is splitted into three tasks:<br>1) Theory and modelling of a confined, high pressure, rotating arc-plasma (energy transport, dissipation and multiscales processes)<br>2) Blending physical model of plasma to non-equilibrium gas and ablative walls<br>3) Building of an experimental database from past measurements and comparisons<br><br>Contrarily to past experience, the expanded flows will be rebuilt from the reservoir to the test section and validated by in situ installed optical diagnostics and sensors. | The hypersonic hyperenthalpic wind tunnel F4 is unique in Europe and has been involved in ground testing for the major space missions, such as ARD, Mars Premier, ExoMars, IXV as a significant contribution to Europe space access and planetary exploration.<br>Although numerous projects have been supported very few in-flight measurements of re-entry conditions are available for Europe (contrarily to US and Russia) so that ground facilities play a major role in missions preparation. Therefore, these specific experimental means need to be enhanced significantly to maintain Europe as a major actor for space access and space exploration. Future space programs for Europe, including tourism economy, is linked to our short-term response to provide reliable means for vehicle design. This dependence is strongly related to the operating level of our European facilities and particularly those like F4 pushing ahead advanced technologies. |
| ONERA | Jean-Luc Vérant | Hypervelocity Earth Atmospheric Re-Entry of Asteroids and Satellites Debris | The objective of this project is to develop and realize an industrial demonstrator tool for the operational forecast of the hypervelocity (from 8km/s to 20km/s) atmospheric Earth entries related to the fall of Near Earth Objects (asteroids) and artificial debris/satellites. The novelty of this project is to provide a unique advanced software computing with accuracy the impact and location probabilities for such objects. These occurrences may lead to fragmentation and dramatic trajectory changes for very high kinetic energy under the scope. Considering sizes from centimetres to hundreds of meters flying at velocity above 8km/s, the following physical processes have to be coupled:<br>- hypervelocity flight involving fragments interactions (proximal bodies flight)<br>- solid mechanics under stress as fragmentation and fracture physics<br>- high energy heat transfer involving ablation, pyrolysis and radiative heat transfer<br>- Aerothermodynamics (ATD) including high energy phenomena coupling plasma to aerodynamics<br><br>Physical modelling (ATD) will be developed allowing short response time scenarios that could occur in Earth atmosphere for unguided objects. The final simulation tool will integrate analytical methods calibrated on up-to-date 3D analysis such as Navier-Stokes, Direct Simulation Monte Carlo, mechanical solver... Each fragment, whatever artificial or natural, will be computationally followed to determine accurately its energy and its trajectory during the atmospheric entry thanks to advanced dynamics/ATD software.<br>Previous documented re-entry debris scenarios such as Mir Russian space station, US Columbia space shuttle, European ATV ones will be reconstructed as well as for the Carancas meteorite scenario. Infrasonic data from TICE network could provide useful results to consolidate developed modelling. Thanks to this simulation tool, realistic scenarios with associated risks will be generated through satellites ready-to-be de-orbited chosen according to European space surveillance needs.<br>Asteroids risk of encounter with Earth (Apophis 2029-2036) will be under the scope of this activity in order to build probable scenarios database of interest for scientific community. | The European space access control is strongly dependent on its short-term capability to address the risk related to satellite debris or NEO. The over-crowded low earth orbits represent a major economical issue for maintaining a safe access to space. The present international policy to clean orbits from their dangerous debris by operating voluntary atmospheric re-entry requires a drastic enhancement of the risk prediction tools. Furthermore, natural object such as asteroids below 1 km length represent a significant environmental risk that Europe has to consider in addition to the present US public effort. Within the 2020 timeframe, Europe could be able to prepare means to protect its population, to guarantee its commercial access to space and to reduce the environmental impact of its space policy for next generations. |

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| ONERA | Jean-Pierre Marque | Low-sized ultra-sensitive accelerometer for The operational monitoring of the atmospheric density of the low Earth orbit for Space Weather survey and forecast. | Operating principle consist in retrieving the atmospheric density from the measurement of the spacecraft acceleration created by the atmospheric drag. This is a new concept of sensor, not based on optics or electromagnetic, which aimed to be embarked as a passenger on different type of satellites and able to cover all the expected range of atmospheric density in a certain domain of altitude and conditions of solar activity (from quiet to stormy). ONERA is the world leader in the field of ultra-sensitive accelerometer, referred as type #1, and has provided the instrument to several space missions as CHAMP, GRACE (NASA) or GOCE (ESA) for the very accurate measurement of the earth gravity field. ONERA has also a recognised know-how in the field of MEMS vibrating beam accelerometer (VBA), referred as type #2, which are subject of several patents and transfer to industrials in aerospace field. The proposed research will consist in working on these two types of accelerometer to make them evolve from their present concept and performance towards the desired instrument. In case of type #1, going from a scientific instrument to an operational sensor needs to merge several competences in mechanics, electronics and signal processing in order to reduce its present budget (volume, mass and power) by approximately a factor 10. In case of type #2, the challenge consists in making the instrument space compliant and improving its resolution to cover the expected measurement range.<br>1 - Definition of the operational needs and measurement objectives<br>2 - Definition of the operational constraints<br>3- Definition of the mechanical and electronic architecture<br>4- Feasibility studies of prototypes of types 1 and 2:<br>b- manufacturing process of the sensor core (type #1)<br>a- micromachining of the MEMS VBA (type #2)<br>b- low-noise, low-power electronic definition (type #1)<br>c- low-noise, low-power electronic oscillator definition (type #2)<br>5 - Development of a prototype and performance evaluation<br>6 - Towards a space instrument and a policy of operation and data analysis<br>Such a sensor measuring the vehicle acceleration is able to meet a large number of other applications as:<br>a. the control of the thrust pulse and velocity increment for the attitude and orbit control of satellite formation flying,<br>b. evaluation and/or control of acceleration or vibration environment on board a space vehicle as ISS,<br>c. scientific applications for the studies of planetary atmosphere,<br>d-servo-controlled test bench (microthrust balance) for low thrust engines, in the 0.1 -100 mN range, for satellites. | Once the feasibility has been demonstrated, the next steps shall be to develop a space instrument and to think about the overall data collect, treatment and analysis by dedicated Services. It should be of a great interest to Europe to have, within GMES for example, a space weather forecast branch taking advantage of the Space Weather Awareness Program of ESA.<br><br>The interest for Europe may consist in taking advantage of ONERA leading position in space accelerometry not only to maintain the European leadership but to extend it to wider applications, adding a brick to a future Space Weather Forecast System and to provide through long duration atmospheric density data, useful information (data base, improved models) for spacecraft design, operation, surveillance and tracking through the improved knowledge of atmospheric drag.<br><br>The ability to be a standard instrument appropriate to any kind of spacecraft without modifying its dedicated mission will allow gathering a large amount of information over months and years to feed Space Weather data base, to improve our model of atmosphere and our knowledge of the relation between its behaviour and the solar activity. |
| Open University | Prof. Charles Cockell | Astrobiology: The search for life beyond the Earth. | Astrobiology investigates the origin, evolution, distribution and future of life beyond the Earth. It seeks to bridge the interface between planetary/astronomical science and biological sciences. To advance astrobiology in Europe several areas of research need to be developed:<br><br>Investigations on the chemistry of the first prebiotic molecules and the emergence of life. These take for the form of laboratory experiments and astrochemistry experiments to study the chemistry of the interstellar medium.<br>The study of life in extreme environments on the Earth, particularly environments analogous in some way to extraterrestrial environments. These studies include investigations of the physiology of organisms that can be sustained in these environments.<br>Research into biomarkers that might give evidence of past and present life elsewhere. The study of the preservation potential and remote detectability of biomarkers.<br>The study of atmospheric processes that can be used to assess extrasolar planets orbiting distant stars for the presence of life. This work includes the modelling of extrasolar planet environments and the potential detectability of gases produced by life. | Europe has a strong history of interdisciplinary science. The merging of planetary/astronomical sciences and biological sciences represents one of the most important and rapidly developing areas of investigation in which Europe has a leading role to play. This area of science is particularly powerful at encouraging young people to take up careers in science and promoting productive research synergies between existing areas of research.<br>The development of astrobiology will encourage a development of European space industry and its capabilities, the development of new types of space instrumentation to study extraterrestrial environments and investigate them for the presence of life, which can be applied to studying the Earth environment, and it will encourage new approaches to space research. Astrobiology also promotes international partnerships. Europe takes a leading role in many space experiments (e./g. ExoMars, EXPOSE orbital facilities etc) and by strengthening this capability we develop the ability to lead initiatives with other nations in these areas. |

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| Progress Control | Dirk van Toledo | To better miniaturized multispectral imaging techniques for earth and planet observation | Multispectral earth and planet observation has been realized, starting from the successful modification of existing spectroscopes so far. In the meantime, combinations of 2D detectors and remote multispectral filters became available in the wavelength band from 400-2.500 nm, so the visible and near infrared spectra.This combination is excellent for miniaturisation and the resulting “mini-multispectral camera MMC” can be a very useful tool for earth and planet observation on board of satellites or mini-satellites.Applications can be found in the domains of the identification of minerals; agro-stress; water pollution; desert and volcano dust; but also in the remote selective health observation of astronauts. | The mini-multispectral camera (MMC) is a tool, which has to be developed and tested in many aspects. This gives a challenge for many researchers in nanotechnology, as well as in remote health observation, useful in space, but also as spin-offs in many other settings, like product selections; security; and microscopy.Since every gram is essential for satellites, miniaturisation spares energy and space. |
| Reaction Engines Limited | Mark Hempsell | Reusable single stage to orbit launch system employing air-breathing and rocket combined cycle propulsion systems | Reaction Engines is currently engaged in the development programme for a reusable single stage to orbit launch system called SKYLON which employs an air-breathing and rocket combined cycle propulsion system called SABRE (Synergistic Air-Breathing Rocket Engine). The programme is largely financed through private equity investment but there is a programme on the engine technology which is part funded by the European Space Agency (ESA). The programme has a target to have the vehicle operational by 2020.SKYLON is an aircraft like vehicle that takes off from a runway, carried 15 tonnes into low earth orbit. The design and technologies of both the airframe and the engines was reviewed in September 2010 and an evaluation report based on this exercise is due from ESA to the UK Space Agency in December 2010. The programme is undergoing the process of forming the, primarily European, consortium, that will complete the development and produce the vehicle. While all the key areas in the baseline design are at TRL4 or above there will be opportunities for European companies to innovate and improve the concept with alterative technology. We have already seen an example of this with a recent technology programme into silicon carbide reinforced titanium struts proving superior to the carbon fibre reinforced struts of the baseline design. The opportunity to improve technologies on the vehicle would be the key rationale for a framework programme. | The SKYLON total programme turnover is estimated between €60 billion and €180 billion, and it will create a secondary industry of at least equivalent value. It is expected to directly generate 26,000 primary high value jobs. Once in operation it is excepted to greatly increase the overall space sector which the UK IGT concluded may reach €400 billion per annual globally. It is possible that the technologies in the spaceplane may have spin out into the wider aviation industry. This potential has been explored in the LAPCAT I programme in Framework 6 and LAPCAT II programme in Framework 7.A reusable spaceplane has a much lower environmental impact per launch than existing expendable launch systems. Once in operations many of the potential applications it enables such as Solar Power Satellites create a large reduction in the impact of mankind’s activity on the earth’s environment. We have found the public reaction to the SKYLON programme is very positive and expect it to be a major inspiration for young people in technical and mathematical subjects. |
| Saint-Petersburg State University of Aerospace Instrumentation (SUAI), Ekvess RnD Center | Dr. Yuriy Sheynin and Dr. Tatiana Solokhina | The development of a unified Russian-European Space electronic platform and its mutual certification for innovative space flight control and data processing systems solving problems of a new generation on a spacecraft board. | The platform should combine the best Russian and European technologies to the design and fabrication of the space radiation- tolerant chips and their certification for the creation of innovative on-board space equipment in order to solve problems that previously could not be resolved on the spacecraft board because of the lack of the necessary electronic components.<br>The main directions of research and development of a unified Russian-European Space electronic platform:<br>- the development of an integrated unified space radiation-tolerant chips design flow on a base joint combined IP-libraries and processors platforms;<br>- the space chips manufacturing for the Russian-European market;<br>- the space chips certification under the basis of European and Russian industry and the use of jointly developed certification centers, standards, mutual certification and test programs for the space application chips;<br>- the development of tools and application software for the space integrated circuits;<br>- the space chips certification on the board of the joint Russian-European satellite technology platforms.<br>The existing background of a unified Russian-European Space electronic platform. Russian electronic industry have its own Multicore platform for the development of the space radiation-tolerant chips of a world- level. On the basis of which were developed chips with SpaceWire standards links competitive with the best world achievements. In addition, Russia has test facilities for the certification of chips, proprietary methodologies and testing programs to meet the chip space requirements, but its electronic production is at a level that Europe has already been achieved. The European space industry is also developing a line of development of electronic components, but it has its own electronic world-class manufacturing and electronic technologies for space applications under the deep submicron, but does not have the volume of their own development and certification, such as Russia. Combining the efforts of both sides to create a single electronic platform can provide unique economic and qualitative impact in the development of joint Russian-European space research. | The expected effectiveness of the Russian-European Space electronic platform:<br>- to reduce the a spacecraft electronics development period in several times;<br>- to reduce the cost of on-board space equipment in more than one order (for example, the cost of the single chip for space application is the tens of thousands of euros now);<br>- to reduce the price of the certification procedures for space application for the electronic components;<br>- to solve by a Russian-European community a new problems at the spacecraft on-board equipment, for example, the problem of ecological monitoring in a real-time of a new quality or co-creating innovative telecommunications equipment with increased bandwidth, etc. by in several times the cost reduction;<br>- to combine the research in the space electronics field of the young scientists and students in Russian and European universities. |

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| SEA Group Ltd, University of Leicester, National Nuclear Laboratory | Dr Chris Chaloner, Dr Richard Ambrosi , Tom Rice | Space Nuclear Power to facilitate Robotic Exploration of the solar system | For robotic exploration beyond the Earth the generation of adequate power from solar arrays is mission-limiting. Surviving the lunar night is extremely difficult and Martian surface operations in winter not feasible. Exploration of the outer planets has to date always been performed with nuclear powered spacecraft. Nuclear power systems offer a means of meeting the demands of Europe's future space exploration programme. In the US, nuclear space power technology has evolved into off-the-shelf modular systems with no counterpart in Europe.<br><br>Specific research to overcome this key capability gap will include activities in the production, extraction, encapsulation and transport of suitable isotopes; the development of protective containment to assure public safety in case of a launch accident; the development of standard units to provide heat to maintain spacecraft systems above their minimum operating temperature; the development of technology (or technologies) to convert the heat output of the nuclear material to electricity; the development of technology to manage the thermal condition of the generator during spacecraft integration and launch; and the safety cases for European launchers<br>.<br>The development of small fission based reactors for terrestrial application offers potential for utilisation of similar systems in space. Research to consider the use of such systems as power supplies for future space stations and planetary bases and in nuclear thermal propulsion would enable the benefits and constraints of such applications to be understood. There is currently no ongoing European research in this area | Nuclear power is an important low carbon technology for the future energy security of Europe and in the context of space exploration is necessary for a more competitive European programme. Their use would result in more capable spacecraft, continuous operation, vehicles and probes that can access cold, dark and inhospitable space and planetary environments. Missions using nuclear power offer better value for money, with one mission delivering the science that might only be achieved with several missions using solar power. Nuclear systems can enable missions that are extremely difficult if not impossible using solar power alone.<br><br>This programme will have additional terrestrial benefits including: more efficient heat to electricity conversion technologies; new encapsulation methods for radioisotopes and; new functional materials; new markets for novel power systems, energy conversion systems or the radioisotopes for these systems.<br><br>Space nuclear power enabling space exploration will further inspire young scientists. The use of technologies developed for space nuclear power will have terrestrial benefits with a positive impact on public opinion. The jobs created will be synergistic with the resurgence of terrestrial nuclear power generation and, as with all space activities, the specific challenges will drive a better understanding of the core physics and technology. |
| Sogei A.p.A. | R. Capua and L.Terranova | Europe-wide uniform high precision positioning services for cadastre and high demanding applications | The research aims at integrating most advanced GNSS technologies for providing a homogeneous, sub decimeter low cost positioning service all around Europe for mapping applications. Main applications needing such service are: Cadastral Surveying, Maps updating, satellite images and orthopothos georeferentiation, transport applications (e.g. ADAS, Assurance and lane keeping systems).Such applications currently need the implementation and maintenance of costly dense GNSS Reference Stations Networks (thousands for the whole Europe).The idea is to work on the integration of most advanced Wide Area RTK positioning and PPP techniques, rover side algorithms and Software Receiver platforms for obtaining low cost High Precision Positioning Services all over Europe. The system has to be based on a Network of a few GNSS Reference Stations over Europe, to be connected in Real-Time to a Control Centre, able to perform long-range errors estimations and provide corrections to the GNSS rover through mobile communication systems. Advanced Rover technologies using Galileo and GPS modernised systems (e.g. TCAR) should be integrated with innovative techniques in order to guarantee low cost and high reliable positioning solutions. Software Receiver (SDR) technology shall be further exploited and has to be adopted in order to reduce installation and maintenance costs of Reference Stations. It can lead to the implementation of Networks of SDR Reference Stations that are totally reconfigurable and upgradeable by the Control Centre (e.g. new GNSS constellations and frequencies can be implemented by software upgrade). The implementation of such Continental High Precision Service has to be carried out involving the reuse of existing Reference Stations Networks (e.g. EGNOS RIMS).The idea has to be developed and validated through Operative Pilot Projects involving all Value Chain Actors, with particular reference to: National Mapping and Geodetic Authorities, Municipalities, Land Registries, Customs, Advanced Guidance Systems Manufactures, Receiver Manufacturers, Land surveyors and Transport Operators. | High Precision Positioning is today needed in important, Never Ending markets, like Land Administration, Cadastre, Geodetic Reference Systems development, etc. Such systems are very important in Development and Post-War Countries, where Coordinates Reference Systems and Land Registries have to be developed from scratch. Furthermore, as usual in Innovative Systems Business cases, high demanding requirements shall be rapidly matched also in the consumer market (e.g. mobile communication services and the switch to high bandwidth systems). Implementation and maintenance Costs for GNSS Networks are currently an entry barrier, both for Service Providers and Users.Current Land Surveyors Addressable Market is in the order of 500000, growing to about 650000 in 2014.A Europe-wide High Precision GNSS Positioning, highly reliable and based on low cost systems, will allow high direct public benefits and Business Opportunities:- Cadastral and Mapping systems efficiency (highly improved numbers of processed parcel subdivisions, transfers of ownership, reduction of boundary disputes)- Business Opportunities (improvements in the number of High Precision service Providers Operators, Improved high precision receivers market, notary transactions, etc..)- 20% growth in of ADAS systems installation in 2020, reduction of car accidents injuries, pay-per-use and low disputes Assurance systems, efficient Customs procedures |
| Space Applications Services NV | Richard Aked | Develop advanced mobile robots, possibly humanoid, to support human exploration. | Humanoid robots of the same size as a person could perform all the activities that a human can i.e. they will be interoperable and ideal assistants to astronauts in pressurised and unpressurised volumes. | Humanoid robot technology will be just as applicable on Earth, as a co worker, assistant or to perform unpleasant tasks.<br>There is a large market potential. |

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| Space Applications Services NV | Richard Aked | Concepts, Tools and Technology for Cost Effective Astronaut Training. | The small number of astronauts and the high cost of developing astronaut training leads to a large cost per hour of training.<br>Research and establish new cognitively grounded concepts to reduce learning time, increase knowledge retention, increase ability to use learned knowledge effectively, etc. | Increased training quality will increase mission success and science return. This research will be just as applicable to terrestrial applications. |
| Space Applications Services NV | Richard Aked | Reduction in the time to develop payloads and spacecraft from typically 10 years from idea to flight to 5 years. | To realise this objective a modern system engineering process with appropriate standards and safeguards will need to be established:<br>- advanced requirements engineering techniques and supporting technologies<br>- advanced collaborative working environments able to include all industrial and academic partners in the development process and not raising barriers to inclusion of SME's<br>- use of digital testbeds, digital integration, digital testing prior to manufacturing. | Regarding payload development the speed of placing payloads in orbit and receiving the resulting science data will increase the speed of the scientific process and of scientific progress.<br><br>Regarding space systems and spacecraft a reduction in development duration should translate into a reduction of cost and allow use of more recent equipment (e.g. a computer processor purchased 10 years ago and used on orbit today has 5 times less capability than current off the shelf processors). |
| Space Applications Services NV | Richard Aked | Prepare ground control centres and User Support and Operations Centres (USOCS) for cost effective Exploration and Science. Prepare these centres to be readily accessible to the general public in a cost effective manner. | Like the ISS exploration missions will be of long duration. There are significant costs for ground support to both manned and unmanned exploration missions.<br><br>Identify the enabling technologies for future cost effective ground operations support.<br>Identify the enabling technologies for reducing the barrier to the general public's participation to on-orbit operations – make them part of the experience.<br>The enabling technologies will include:<br>- Semantically enabled Service Oriented Architectures or similar<br>- intelligent and agent based systems for automation and interaction with ground operations personnel and the public<br>- extremely high quality multi-modal interaction (graphical, visual, audio, haptic and tactile) experiences of in orbit exploration and science e.g. "walk on Mars"<br>Incrementally develop and apply these technologies to the existing control centre infrastructure until ready for exploration. | Technology that decreases the operation cost of complex industrial processes will provide benefits to the non space industry.<br>High quality involvement and interaction with the general public will stimulate interest in young and old. |
| Space Applications Services NV | Richard Aked | Establish In-situ Resource Utilisation (ISRU) technologies | Long distance missions need fuel to return and need to carry life support and food supplies.<br>If ISRU can provide the needed air, water and fuel at the exploration destination the launch mass of exploration missions can be significantly reduced.<br>Research ISRU technologies for the production of:<br>- fuel<br>- air<br>- water | This technology could enable missions at a significantly lower cost.<br>This research on biological and chemical processes will be applicable to terrestrial applications. |

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| Space Applications Services NV | Richard Aked | Establish computer aided medical and surgical systems to maintain crew health on long missions | Long duration missions have many risks for the astronauts. All ailments can not be identified by a pre-mission screening and accidents will occur resulting in injury.<br>Research and develop compact, lightweight medical and surgery support systems able to work at long distance without 'on-site' expert surgeon support.<br>Research covering:<br>- medical robotics<br>- intelligent surgery and medical support systems<br>- nano technology<br>- virtual reality and augmented reality support systems<br>- data processing and diagnosis systems | This technology will support astronauts health maintenance.<br>This research will be just as applicable to terrestrial applications. |
| Space Applications Services NV | Richard Aked | Establishment of electronic companions to provide personal psychosocial and therapeutic support | Long duration missions, in small groups, isolated from every day social contacts on Earth lead to significant stressors which can change human behaviour.<br>Such behavioural changes are embarrassing to discuss with others and others are not always qualified to provide good advice.<br><br>Research the needs and technologies to develop personal electronic companions that can support and guide an astronaut through demanding psychosocial situations. | This technology will support astronauts in maintaining a balanced view and provide therapeutic support in the case of mental illness.<br>This research will be just as applicable to terrestrial applications. |
| Space Applications Services NV | Richard Aked | The knowledge and techniques available today to design an adequate habitat for a long duration mission are not complete. The challenge is:'How to design a habitat that is suitable for a long duration mission and have confidence that the design is adequate prior to the mission' | Habitability is comprises physiology, psychosociology and psychology. A habitat design which is inadequate physiologically can lead to death; a habitat design that is inadequate in the psychosociological domain can contribute to the crew not working as a team, or worse; a habitat design that is inadequate in the psychological domain can contribute to individual crew mental health disorders.Research psychosociology and psychology to establish an understanding of theses subjects to enable adequate habitats to be designed.- understand the issues- develop models of human behaviour in various environments- validate these models | Understanding how humans behave alone and in groups is valuable not only for space but for any activity where humans must collaborate. This research will improve the design of work groups and their work environments as well as home environments. |

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| Space Applications Services NV | Richard Aked | Man-System Interaction & Intelligent Systems for Exploration | Exploration systems will have long lifetimes and will in some cases be systems of systems. Some systems will be unmanned, some will be manned temporarily and some will be manned permanently.<br><br>Research and establish techniques and methods which will help ensure man-machine collaboration is optimal and that astronauts in a hostile environment do not have to 'fight' the system.<br>Research subjects should include:<br>- situation awareness<br>- levels of automation and intelligence<br>- natural (language, gestures, expressions)man-machine interaction<br>- feel good factors | Understanding how humans behave alone and in groups is valuable not only for space but for any activity where humans must collaborate. This research will improve the design of work groups and their work environments as well as home environments. |
| Space Exploration Institute, SPACE-X | Jean-Luc Josset and Alain Sandoz | Research and Development of Wireless Radio Frequency (RF) Technologies for Space and Planetary Exploration: Enhanced Operational Potential of Scientific Payloads and Integration into Space Mission Infrastructures | In the foreseeable future all equipment destined faraway will remain manufactured on earth and reducing mass of space-borne components will remain a strong constraint of space exploration missions. Just considering the possibility of replacing a wire between a central unit and a device by two low-mass wireless interfaces reduces the mass and the complexity of the harness. Wireless communication increases effectiveness of the device by better adapting its location to its goals. For devices that are used only once or that have very low power consumption during their life span, decentralizing the necessary power supply or source at the shared location of the device and its wireless command interface module further reduces the need for power cables. The ability to multiply devices for monitoring the spacecraft or to control complex equipments in a new way opens up new applications with high potential profitability from the mission perspective. However, this thematic must be considered at the global level of the wireless RF function, i.e. a transversal subsystem, interfacing and interacting with other spacecraft subsystems like structure, harness, power, payload, or ground segment. Today, wireless technology is not commonly found in space for tasks related to monitoring and controlling spacecraft equipment. In particular, the lack of a standardized technical approach global to the spacecraft for the systematic usage of wireless technology on board confines this idea to the periphery of R&D. To make significant progress on the topic it will be necessary to consider a global approach, comprising both the wireless function and the potential impacts on its environment, the spacecraft itself and its MAIT. The time-span of FP8 is the right moment to undertake a concentrated effort aimed at tapping the potential and impacts of a wireless function on space-borne equipment destined for space exploration research and activities. | It is essential that Europe address this research challenge because future space and planetary exploration will be undertaken at the European level or at higher levels of international cooperation. Neither individual nations, nor space industries, though for different reasons, today have the incentive to develop the necessary technologies for a wide spread usage of the wireless RF function for space exploration. European space industries and European space exploration would both benefit directly from<br>the initiative already in the time-span of FP8 and in the context of calls and preparation of upcoming ESA space and planetary exploration missions (e.g. EJSM). Also, non-space related industrial sectors in Europe could benefit from new developments in low mass, low energy, miniaturized wireless technologies working in harsh environments for terrestrial applications. Sustainable space exploration, through a reduction of costs and an increase of efficiency, will maintain a potential of involvement and therefore a high level of inspiration of young Europeans researchers and engineers in space and planetary exploration. |
| Space Research Institute, Austrian Academy of Sciences | Maxim Khodachenko | Development of structured data and knowledge management/operation system | Acquisition of experimental data by space mission measurements and interpretation of these data on the basis of developed theoretical concepts and models are two major mutually connected aspects of the modern space research. Numerical modelling, as a way to reproduce complex natural phenomena and to understand them by computational simulation, plays here an important role. By this, the observational data on one hand are considered as a verification test for validity checking of existing models, on another hand they appear a driver for further improvement of existing models and development of new ones. Many of the scientific goals of planetary space missions require robust models of cosmic objects and environments, as well as efficient observational and measurement technologies for collection and delivery of experimental data, to ensure successful exploration. Europe has great strength in both these areas, but joint simultaneous use of experimental data and computational models is still rather fragmented. The scientific potentials of the combined use of experimental data and numerical models in their mutually complimentary way are still not realized. Individual research and space mission groups, data bases, models, and techniques need to be coupled and cross-coordinated. Creation of an integrated IT framework where numerical models are interconnected to the experimental data and used in combination with the last for simulation of space phenomena and interpretation of measurements, provided by space missions is an actual task. Progress on that way will enhance the efficiency of space mission data exploitation on one hand, and serve as a tool for better preparation of mission operations and solving various technological issues, including preparation of new missions, on the other hand. It will also provide an environment for testing and further improvement of existing models versus experimental data. | This will bring data and models outside of mission teams and specialized computational modelling groups, making them accessible and useful for a broad scientific community. Common operation of both types of data (measured and modelled) in their interconnection and mutual complimentarity will ensure a longer and more efficient use of space mission data in the worldwide research community, also far beyond a particular mission duration timeframe, increasing naturally added value of the European space mission investments. Existing level of scientific cooperation, as well as the technical capabilities for interactive communication of researchers and access to remote databases and computing infrastructures, provide favourable conditions for development an integrated modelling and data operation environment. Operation, visualization and analysis of data measured by space missions, located sometimes in the remote databases, may be related as a work of so-called Virtual Observatory (VO). The concept of VO is now very popular among the scientific circles. However, a special task which has to be emphasized in that context consists in the necessity to build a 'bridge' that fills the gap between the space mission observational data and computational models, having in mind that that last reflect actual scientific knowledge about the considered physical phenomena. |

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| SRON Netherlands Institute for Space Research | Dr. Avri Selig | Comparative Planetology. Addressing key scientific questions concerning the atmosphere of the earth, the solar system planets and exoplanets by making use of the common methodologies in the research fields. | Our understanding of the Earth's atmosphere and climate, our knowledge of the structure and properties of solar-system planet atmospheres as well as our first views of the atmospheres of exoplanets all critically depend on understanding and characterizing aerosol and clouds in those atmospheres. Typically, the uncertainty of (negative) radiative forcing due to aerosol in the earth atmosphere is of the same order as the total (positive) radiative forcing due to the CO2 greenhouse gas (IPCC 2007).<br>The common measurement methodology necessary to better quantify the effect of aerosol and clouds in all planetary atmospheres is spectropolarimetry. Measuring the amount of linearly polarized light and its direction as a function of wavelength from those atmospheres (and surfaces in the case of the Earth, Mars, Titan, and rocky exoplanets) due to reflected sun and starlight adds unique and crucial diagnostic value that cannot be obtained from the usually applied total flux/intensity observations alone. Moreover, with spectropolarimetry detecting and characterizing exoplanets from space in synergy with planned observation from ground come into scope. Thus, potential conditions for life can be determined by distinguishing the scattered and therefore polarized light by exoplanetary atmospheres from the unscattered stellar (unpolarized) stellar light.<br><br>What is needed is the development and application of a comparative planetology infrastructure:<br>• A common multidisciplinary collaboration for the further development of coupled atmosphere/surface models for the retrieval of cloud/aerosol properties and surface properties<br>• The development and ground-based validation of new concepts for dedicated miniaturized space instruments which can simultaneously measure flux and the degree of polarization as a function of wavelength at various viewing angles<br>• Data assimilation schemes of (new) ground-based measurements with (new) satellite measurements<br>• Platform for proof-of-concept demonstration (e.g. ISS or dedicated microsatellite) of new instrument concepts.<br>It is assumed that the realization of dedicated flight instruments is funded by ESA. | Connecting research communities<br>Comparative planetology is multidisciplinary and connects research of the Earth Atmosphere, planetary atmospheres and exoplanetary atmospheres. Establishing and promoting this multidisciplinary research field will be a strong forcing to bring the best scientific practices, expertise and knowledge together, now existing in the communities of Earth Science, Planet Science and Astrophysics.<br><br>Young Europeans<br>The key scientific questions today of comparative planetology and its potential scientific and societal impact will attract young European academics from various disciplines to work together in a new joint research field.<br><br>Collaboration between European Academia, Research Centres and Industry<br>Innovative measuring concepts, modelling of coupled atmosphere/surface systems and data assimilation schemes ask for creative solutions and close collaboration between Academia, Research Centres and Industry.<br><br>Environment<br>Spectropolarimetry is the essential observation methodology to study aerosol and cloud properties. The uncertainty on (negative) radiative forcing due to aerosol/clouds is as large as the total (positive) radiative forcing of CO2 (IPCC 2007). Reducing this uncertainty is of key importance for future climate projections. |
| SRON Netherlands Institute for Space Research | Dr. J.W. den Herder | Critical technologies for cryogenic photon counting detectors | Imaging spectroscopy, the simultaneous measurement of the position and energy of a photon, is becoming increasingly important for space missions. Future advances in high and low energy astrophysics but also in earth observation, require such capability. Key challenges are to obtain a good energy resolution for large detector arrays. One of the main approaches to achieve this is to use cryogenic detectors where the thermal noise in the detector is effectively eliminated leading to ultimate sensitivity. This approach is followed in a large range of applications from sub-mm to X-rays. These detectors are often cooled to the sub-K level and this poses a major challenge to a number of generic technologies:- Multiplexing of a large number of elements in a detector array into a single channel. Different approaches are emerging of which some have the promise to cover a range between submm and X-rays (e.g. microwave readout)- The development of versatile and compact wiring and interconnections between the cold detectors and the ambient environment (e.g. wire bridges, bump bonding)- The development of compact and efficient cooling systems from 4K to the subK level. Technology to cool down to 4K is widely under development but for the last stage a reliable and compact cooler is crucialIt is proposed that these basic technologies will be included in the FP8 work program. The aim is to increase the typical number of detector elements which can be read-out from 1000 detector elements (current design goals) to 100.000 detector elements in the FP8 time frame. Combining these technologies with detectors also under development in Europe, it will be possible to realize future cutting edge space instrumentation. As part of this part of the FP8 program also the combination of these technologies in new instruments is foreseen at the level of demonstrating the basic performance. | Clearly development of these critical technologies is important for European non-dependence (or even better to take a lead in these fields). Detectors which combine spectral and imaging capability will likely have a spin-off in ground applications. Submm detectors can be used for security (body inspections for weapons) whereas, on the other side, X-ray applications can be used for material research (X-ray fluorescence in materials analysis). Currently these applications are commercially less attractive due to the required cooling which make them large and expensive. With the proposed program we expect to reduce the thermal loads, mass and complexity considerably enabling and stimulating many earth applications. |

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| Surrey Space Centre, University of Surrey | Dr. Vaios Lappas | The Impact and Opportunity of Small Satellites for Space Research | Small satellites allow for the low cost and frequent demonstration of a range of key space technologies and space missions, such as space debris/satellite Deorbiting, remote sensing in constellations, navigation systems, interplanetary travel. Specifically cubesats, nanosats and microsats can enable the rapid progression of the Technology Readiness Level (TRL) in the most cost effective manner thus pushing the boundaries of innovation in many areas such as propulsion, controls, embedded systems. There is a growing need to conduct more practical space research with flight demonstrators with a better mix of universities and industry as current funding streams from conventional sponsors such as national science budgets or ESA are being cut or changing focus on supporting more operational systems/science missions. Small satellites can enable new technologies to multiply and be rapidly tested increasing competitiveness in Europe, increase the technology base in Europe and contribute on the generation of new businesses and jobs. For example the UK goverments investment in small satellite investment through the MOSAIC program on small satellites lead to the award of the Galileo contract to SSTL; the development of a new mission concepts such as the Disaster Monitoring Constellation and the qualification of many new space technologies currently used in operational space systems. | Small satellites can foster greater impact through quick science, engineering, education and job returns. Demonstration of new technology and mission concepts become a 'force multiplier' that can accelerate development and increase job growth. Based on the Surrey small satellite paradigm, a new generation of entrepreneurs, engineers and scientists have already been making their impact in the space community. |
| Technical University of Denmark, DTU Space | Per Høeg | Establish experimental knowledge of the global lower stratosphere water vapour distribution and its impact on the climate system.<br>Develop the necessary technologies for space application for monitoring the region. | Central to most of the least understood internal feedback mechanisms of climate models are those associated with water vapour. Lower stratosphere water vapour (in the UTLS region) plays a crucial role in decreasing the global average temperature, as seen in observation from year 2000. This needs to be addressed in depth applying dedicated space observation of this part of the atmosphere region.<br>This can be done by starting a space instrument development (at the absorption lines around 23 and 183 GHz) for limb sounding monitoring of the global height profiles of UTLS water vapour, and make sure that such novel and new instrumentation would fly on one of the coming satellite missions within the GMES programme (Sentinels), for example.<br>In order to complete the picture and make the predictions for the future climate trends and development more precise, an improved stratosphere model is required for climate system models, as the new EC-Earth climate model, together with methods for variational assimilation of the observations. | The motivation for Europe would be to gain competence in high frequency sounding techniques for space, which eventually also will prove beneficial for the future satellite communication of HD-TV signals.<br>By assessing more precisely, through observations and climate model studies, the trends in the climate, European decision makers will have a new solid tool for their changes in the society in order to minimize the changing climate impacts on daily living. |
| Tele-Rilevamento Europa S.r.l. | Fabrizio Resta | A digital platform for city monitoring, integrating the usual optical data with high resolution (X band) satellite radar data regularly updated. | Beyond the information on building movements (using InSar techniques), used by the Civil Protection, radar images also allows to monitor changes in the urban environment (using change detection techniques) with a frequency today unimaginable.<br>Developing specific algorithms for radar data and with the integration with optical data it could also be possible to obtain information related to a digital model of the evolution of the cities.<br>With the results obtained from this project we could obtain a platform to monitor "how and where the city is changing" creating an important historical database for European Regions. | The main impact of this project is to control cities environment, having historical information, to make analysis of risks and to make the necessary intervention to avoid them.<br>Many accidents are consequence of man activity and some natural disaster may be predicted, the possibility to create an historical database, using different technologies, will allow to analyse, predict and intervene to avoid natural or human created disasters.<br>The results of this research will allow engineering companies to monitor the impact of construction sites on the concerned area; Public Authority to monitor unauthorized buildings and update land registry; Insurance companies to evaluate risk costs.<br>A performing territorial information system integrating natively different technologies, will allow to have a better understanding of the changes of our cities. |

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| Thales Alenia Space Italia S.p.A. – Business Sector Space Infrastructures & Transportation | Enrico Gaia | Development concepts and technologies for re-supply/maintenance platforms, these can provide a step forward for space exploration as well as for commercial LEO/GEO and bust Europe in commercial space market. | Develop on-orbit assembly capabilities and technologies to build permanent re-supply/maintenance platforms in both LEO and GEO capable of assembly and servicing of both exploration and commercial systems. This includes the following objectives:<br>- Technologies and capabilities to capture of collaborative / non collaborative objects.<br>- Mechatronics for docking/berthing, servicing and manipulations capabilities supported by arms and other effectors based on human collaborative robotics capable of high level of autonomy and at the same time maintaining human in the loop (this is a transversal technological research not limited to space applications).<br>- Develop concepts and technologies for fuels exchange/transfer in space either by exchange of tanks/motors or direct transfer of fluids (including cryogenic).<br>- Develop innovative spacecraft development processes and related technologies capable to make possible the development of space systems able to be assembled re-supplied and reconfigured in orbit.<br>- Develop innovative simulation systems that will enable complete virtual spacecraft development and verification and especially making possible on-orbit final assembly and verification. | These technologies and capabilities are enabling space explorations and are capable to open and support European companies in space commercialisation. Only common development of these technologies can make these developments feasible in Europe because in this way the two domains can put their resources in common.<br>For example telecommunications and science payloads are becoming more and more complex and demanding in terms of mass and dimensions and launchers are less and less able to send complete systems in orbit, more over a launch failure can jeopardise entire services. Often scientific satellites mission results are not optimum because it is not feasible to upgrade equipment during the project and close to launch, on the other hands the successes of Hubble Telescope maintenance and upgrade have shown the potentiality of this concept. European space enterprises capability to propose integrated solutions to the commercial market can make them major players in global space commercialisation. On the other hand since the size of Space Exploration enterprises requires international cooperation, these technologies can enable Europe to take a central role in these enterprises. |
| ULB | André Preumont | Adaptive large lightweight deployable reflectors | Large, light-weight reflectors in space are considered key elements enabling future Earth observation (monitoring resources and environmental changes, weather forecast and hazard assessment) as well as space science missions. Monolithic reflectors are limited in size, due to mass and volume restrictions imposed by today's launch capabilities. Large size reflectors (from several meters to tens of meters) need to be lightweight and deployed in space, and controlled to maintain the surface figure accuracy compatible with the wavelength observed.<br>Actively controlled membrane reflectors have the potential for achieving an areal density below 3 kg/m² with the required shape accuracy. The problem is a challenging mix of material sciences, fabrication process and shape control. | Large reflectors are in demand for earth and space science missions. Most of the effort in this direction is conducted in the USA. Europe is lagging behind, but has highly competent teams, both in industry and in academia, capable of providing a solution within the next 10 years. This research has the potential for producing new breakthroughs in the level of detail of the observation of the earth, in the objects studied in outer space, and will drive new findings in electroactive polymers as well as control. All these aspects will inspire young researchers. |
| Uninova | Rita Ribeiro | Decision Support Systems for Space Operations | Ground-based spacecraft operation (SO) is a large optimization problem. Over the course of a mission, the operations team continuously trades-off two broad classes of requirements: (1) user demands, and (2) spacecraft lifetime. Existing control environments are mostly geared towards meeting user demands and the everyday tasks of flying a spacecraft safely–as they are mission-critical systems; typically, they are not directly integrated with other systems. SO engineers (and external experts) must therefore use ad-hoc and mission-specific solutions for important mission-related analyses–e.g. optimize scheduling of usage or investigate abnormal behaviour of a spacecraft component. Critically, these analyses eventually lead to decisions regarding spacecraft operations that currently are not supported by any integrated system.<br>In this context, one challenge for space research is a general Decision Support Systems (DSS) architecture for space operations. The standard view of a DSS includes three parts: (1) a database for the domain; (2) a model of the decision problem, and (3) a graphical user interface that allows exploration of the decision problem–successful systems were also meant to increase the efficiency and efficacy of decisions, not replace decision-makers. DSS are now routinely used in industry and there is a large body of knowledge regarding DSS design<br>A general space operations DSS framework, nevertheless, must address specific needs of this domain: no systematic modelling exists of the decision problems SO engineers encounter; critical data can come from outside the spacecraft control environment; principled database design does not exist for the type of data generated by SO; and space operations pose particular ergonomic problems to user interface design. Finally, a truly general framework should be multi-mission–fostering reusability and communication across missions–and also provide functionalities to a heterogeneous user base of operations engineers, other teams inside ESA, manufacturers, and end-users. Put together, this challenge demands new R&D on decision-making within SO environments, telemetry databases integrated with other data sources for decision support purposes and human interface design in the space operations domain. | The combination of long-term storage of telemetry, external data sources, flexible reporting capabilities, and support to the decision-maker has three main benefits to space operations: (1) efficient and systematic analyses for standard and ad-hoc tasks; (2) different spacecraft components, perhaps across different missions, may be analyzed together, promoting reusability and sharing of common knowledge; and (3) ultimately supports the goal of maximizing spacecraft lifetime and availability.<br><br>A more ambitious perspective reveals a larger impact. The data and knowledge produced by a mission have a potential use that is not restricted to the mission itself. Manufacturers and other researchers of space components, given a particular design, wish to build models of a device's performance under normal and adverse conditions, its degradation over time, and how it fails; SO engineers also regularly interact with outside experts of a particular spacecraft component during a mission. This bidirectional link–important for the design of future spacecrafts–has no systematic support.<br><br>An architecture that in addition is also open to other external users can provide data that is scientifically relevant but not necessarily part of the payload–and the impact of freely available data on basic research, and educational settings, can be considerable.<br>All of the above have larger implications in basic and applied research, industry contracts, and dissemination of space activities |

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| Université Libre de Bruxelles | Prof. Jean Claude Legros | I support ELGRA<br>Microgravity related research within Europe.<br>.Development of a retrievable scientific Platform | I started to use microgravity from 1984. I conducted experiments on Spacelab (4 moissions) Eureca, sounding rockets and more recently on ISS and Foton .<br><br>I support development of a European autonomous retrievable scientific platform.<br>This would bring a lot of flexibility to perform experiments in Physics, Heat transfer, materials processing. | I support the following text from J. Van Loon - ELGRA<br>Space programs including human space flight and microgravity research and technology is an important drive to a communities' innovative and educational capacity.<br>The microgravity environment of space provides a unique platform to perform studies in physical and life sciences and technology. Understanding processes in fluid behaviour, material and plasma physics, human physiology and plant and cell biology are important for basics knowledge but also for application in society.<br>Adaptations of the human body to space are not well understood and more research is needed. What we presently do understand is that astronauts' body adaptations have several similarities to the process of ageing. An ageing is population is one of the challenges Europe is facing in the coming decade. More knowledge is required to understand and tackle this problem economically.<br>Protocols and technology developed through a dedicated European Space program will support such an effort.<br>The space program and especially human space flight and exploration has always been an huge inspiration for youngsters. Space and microgravity related sciences should be used more to have young people engaged in science and technology within Europe. We would encourage the commission to have a strong program on this in coming FP8 activities. |
| University of Goettingen, Institute for Asstrophysics | Dr. Volker Bothmer | Quantification of the physics of the Sun-Earth system towards operational space weather forecasts. | Analysis, interpretation and modelling of simultaneous data from multi-point space missions operating in the Sun-Earth system and heliosphere in conjunction with dedicated ground-based networks. Development of relevant hardware and software techniques in order to establish an operational space weather infrastructure to help support future robotic and human space missions and its technological requirements. | In the context of the EU/ESA space situational awareness programme the research will establish the necessary technical and scientific ground to help protect critical European infrastructures in space (e.g., Galileo) and on ground (e.g., power grids) and will be crucial for Europeans future of space exploration. |
| VEGA Deutschland GmbH | David Salt | European technology research and application development for routine low cost sub-orbital space launch services. | Today, access to space is severely limited by the nature of current launch systems, whose expendable design and low flight frequency makes them both expensive and unreliable. As a consequence, scientific research and industrial applications that rely upon the unique nature of the space environment (vacuum, micro-gravity, etc.) and the observational perspectives that it offers are either very restricted or remain essentially unrealised. However, this situation will change in the next few years as organisations based mostly in the United States develop fleets of small, highly reusable vehicles to offer routine low cost sub-orbital space launch services.<br><br>To help foster the development of this paradigm shift in space access, President Obama established the Commercial Reusable Sun-orbital Research (CRuSR) programme in 2009, intended to help bring together the future service providers with their potential users and thereby stimulate both the nascent industry and its emerging markets. More recently, Congress has authorised $15 million in annual funding from 2011 for CRuSR that will purchase initial flights to demonstrate the value of suborbital research to private business and other scientific and technological user communities.<br><br>A similar initiative within FP8 would both educate and enable the European research and industrial communities, preparing them to take maximum advantage of these new capabilities and thereby stimulate development of future down-stream markets and associated service within Europe.<br><br>Such an initiative would complement and build upon previous initiatives within ESA (e.g. Columbus exploitation) and the EU (e.g. IMPRESS) while providing a stimulus for future as yet unforeseen applications in the fields of engineering and science. It would also provide a forum for identification, discussion and resolution of the complex legal and regulatory issues as well as financial concerns such as funding and markets. | Europe does not lack the entrepreneurs and engineers needed to develop the systems needed for low-cost sub-orbital space access and the services based on them. However, complex legal and regulatory structures and lack of focused financing means that, once again, other economic blocks are taking the lead.<br><br>This proposed initiative will promote regular, frequent, and predictable access to the edge of space at a reasonable cost with easy recovery of intact payloads which is critical to broadening the base of future space markets through low cost access to the space environment. More specifically, it will foster commercial operators who are currently considering the lease and operation of these systems within European territories.<br><br>Realising cheap and frequent access to the space environment will also enable young Europeans to explore and eventually experience its vast potential for improving life on Earth. Moreover, by enabling frequent and direct measurements/sampling of those parts of the atmosphere that are not currently accessible to scientists, it will enhance our understanding of some of the key processes involved in climate change as well as other important environmental issues. |