

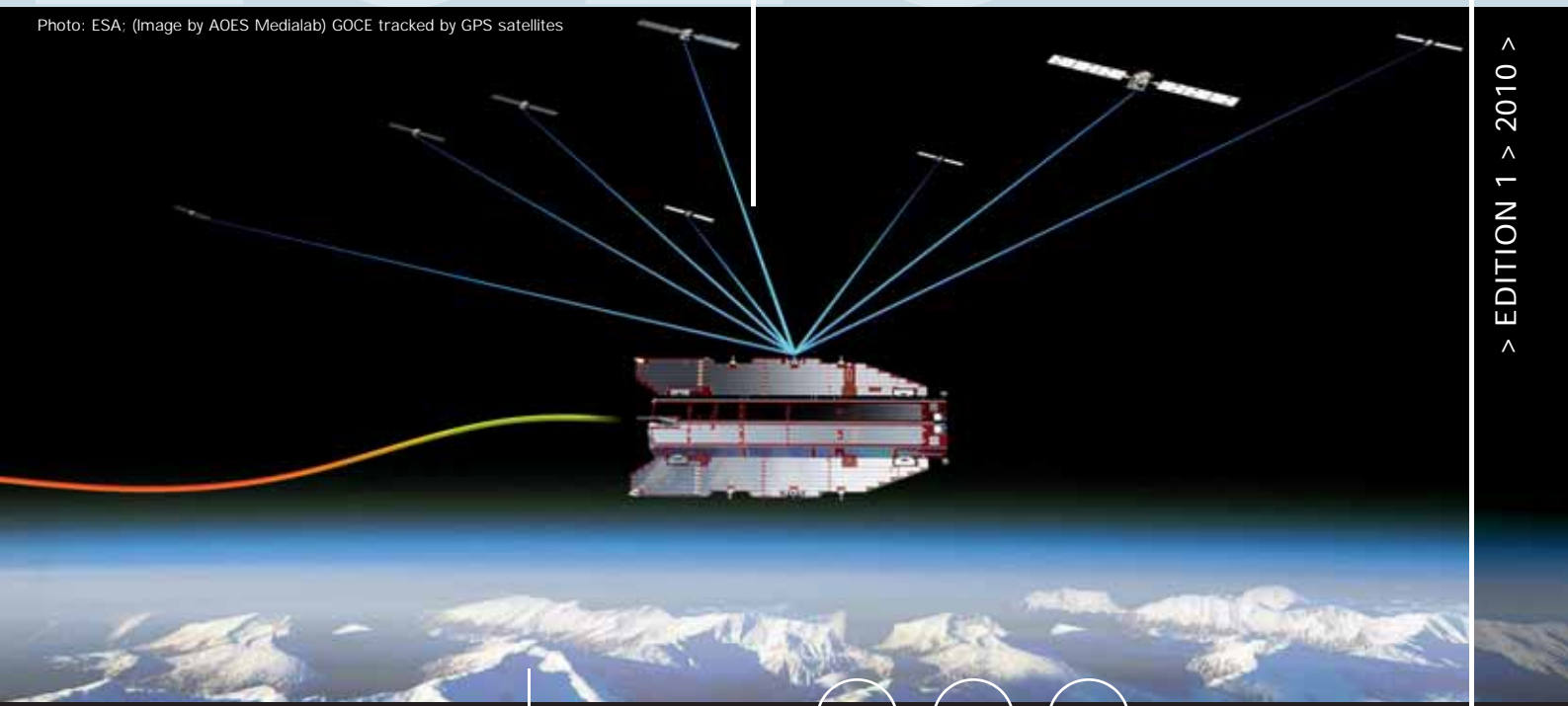
Austrian Space Applications Programme

> **asap** >

Projects - 5th and 6th Call for Proposals

2010

Photo: ESA; (Image by AOES Medialab) GOCE tracked by GPS satellites



> EDITION 1 > 2010 >





Preface

Space technology is regarded as an area of strategic importance for all industrialised nations. It not only is an important sector of industry, it also makes major contributions to the promotion of scientific research and facilitates the accomplishment of the government's infrastructure responsibilities in a dynamic knowledge-based society. Space activities are important for the fields of mobility and transport, telecommunications, environmental and climate research, astronomy and Earth sciences.

Space technologies are a worldwide market with dynamic growth. In order to support Austrian science and industry to increase their importance in this market the Federal Ministry for Transport, Innovation and Technology (bmvit) initiated a national Space Programme, the Austrian Space Applications Programme ASAP, a bottom-up programme targeted at space science, technology and applications.

The main objectives of the Austrian space policy are to strengthen the position of the Austrian Space Cluster on the commercial market and to support international and bilateral cooperation on the one hand and, on the other hand, to promote optimal use of space technologies for commercial products and services and for space applications and space research.

ASAP prepares, supports and complements our participation in bilateral and international programmes, in particular of ESA and EU. The national programme enables us to support scientific participation, build interesting technology niches for Austria and use the potential of space based applications. These applications concern the fields of remote sensing, telecommunications and navigation with increasing importance of the combination of these service domains. As a general strategy, focus is laid on applications of space technologies in particular on the promising fields of Earth observation and satellite navigation.

This 3rd edition of the publication of successful projects supported and funded by the national space programme in 2007 and 2008 shows that the Austrian space community is well prepared for important coordinating roles within international programmes. The national projects lead to applied scientific missions or to technologically interesting components and equipments for Austria.

To prepare the implementation of GMES in Austria, an "action-line GMES in Austria" was designed in 2007 and 2008, that provided additional funds. The new possibility for the community was presented via a roadshow. It informed the community in the Austrian space regions. Many new users took advantage of the special opportunity, which could be shown by the overwhelming participation in this field and the excellent projects. As one of the biggest outcomes, a space-SME created a concept for a nationwide data model for land-use and land-cover (LISA). While building the concept, the team could find new co-operators and at the end of the first phase the team, amongst others, included all nine Austrian federal states.

Having a look on the results and impact of the programme we see an increase in the number of participating organisations and cooperation and also in the variety of new topics which could be explored. Since 2002 the programme has provided space-interested and creative people and organisations with the opportunity to let their ideas become great projects. The national space programme supported a group of young students to develop, assemble and test the first Austrian nanosatellite "BRITE/TUGSAT" to train young experts for an entire space mission.

There is a long list of excellent projects: In this brochure you will find 72 projects of the national programme funded in 2007 and 2008. This all is a vivid sign of the broad expertise and the success of the Austrian space community and of the national funding sustainability.



A handwritten signature in black ink that reads "Doris Bures". The signature is fluid and cursive, written on a light-colored background.

Doris Bures
Federal Minister
Austrian Federal Ministry for Transport,
Innovation and Technology

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Austrian Space Applications Programme



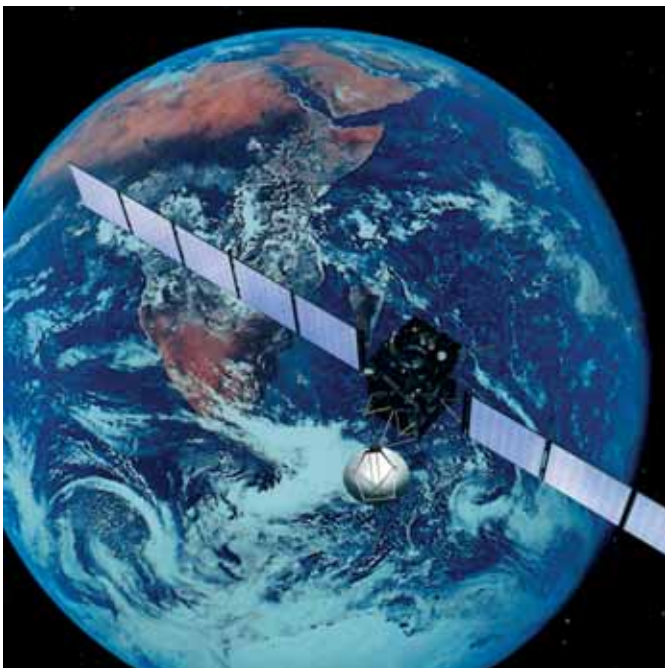
Programme Description

The Austrian Space Applications Programme ASAP was initiated by the Federal Ministry for Transport, Innovation and Technology (bmvit) in 2002. It is a bottom-up research funding programme targeted at space science, technology and applications. The programme should enable bilateral cooperation, support scientific participation in ESA and bilateral projects and complement development in the application domain. It also aims at promoting interesting technology niches in Austria. The Austrian Space Applications Programme addresses Austrian and international scientists, scientific institutions, industrial enterprises and other companies, including SMEs located in Austria.

Through ASAP Austrian research institutions as well as commercial enterprises have been supported in their efforts in conducting space science and exploration projects, and in developing space technologies, products and services.

The programme elements "Scientific Excellence", "Economic Benefits" and "Benefits for Society" are affected by the main objectives of the Austrian Space Applications Programme:

- > Development of scientific instruments for European and international space missions
- > Building new scientific skills within the scope of space missions
- > Development of innovative technologies, products and processes
- > Diffusion of space technologies in other sectors
- > Utilisation of space technology for further applications like navigation, telecommunication, Earth observation and integrated applications
- > Use the potential of space based applications to contribute solutions to the great challenges of our future



Furthermore, ASAP, Austrian Space Applications Programme, on the one hand aims at building national and international networks through multi- and bilateral projects and on the other hand at increasing user communities of space technology.

Earth Observation

ACCU-Clouds

AT-X

e_SPIDER

ENVICHANGE

GEOID+

GOCONAUT

ICEAGE

NAVLAS

PAT+3

TripleM

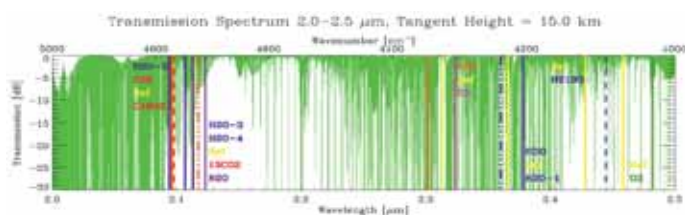
ACCU-Clouds

Preparing a Key Dimension of ACCURATE Climate Utility: Cloud sensing and Greenhouse Gas Profiling in Cloudy Air

The ACCURATE (Atmospheric Climate and Chemistry in the UTLS Region and Climate Trends Explorer) satellite mission enables joint atmospheric profiling of greenhouse gases, thermodynamic variables, and wind in the upper troposphere and lower stratosphere (UTLS) and beyond. It achieves this unprecedented scope by employing inter-satellite signal links between Low Earth Orbit (LEO) satellites, combining LEO-to-LEO microwave occultation with LEO-to-LEO infrared-laser occultation (LIO). This novel concept was conceived at the WegCenter and proposed by an international team of more than 20 scientific partners from more than 12 countries to an ESA selection process for future Earth Explorer Missions. While not selected for formal pre-phase A study in 2006, because it was partly immature at that time, it received very positive evaluations and was recommended for further study and development.

On this basis FFG-ALR has funded pioneering initial projects under previous ASAP calls (ACCURAIT, EOPSCLIM) and ESA supports studies as well. ACCU-Clouds builds on these activities as an innovative project complementing the ESA studies in the key dimension of providing cloud sensing and cloudy-air greenhouse gas profiling capabilities.

Related to this pivotal potential for climate change monitoring and research, ACCU-Clouds prepares novel scientific algorithms for retrieving cloud extinction, cloud layering, and cloudy-air greenhouse gas profiles from LIO data. These algorithms are seamlessly embedded into WegCenter's occultation software system (EGOPS), also used to integrate all ESA study developments. Furthermore, in order to test the advanced system, an end-to-end performance analysis is undertaken, which uses the new cloudy-air greenhouse gas profiling capability to assess its uniqueness for climate science. Results show that the detection of clouds works in a highly reliable way and greenhouse gas concentrations are accurately derived in all conditions not blocked by clouds. Overall ACCU-Clouds represents a crucial milestone on the way towards realizing an ACCURATE mission for the benefit of monitoring the changing atmospheric composition and climate in the 21st century.



Measurement channels for IR-laser signals in the 2–2.5 micrometer wavelength region.

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Infobox

Project duration:

1 July 2009 – 28 February 2011

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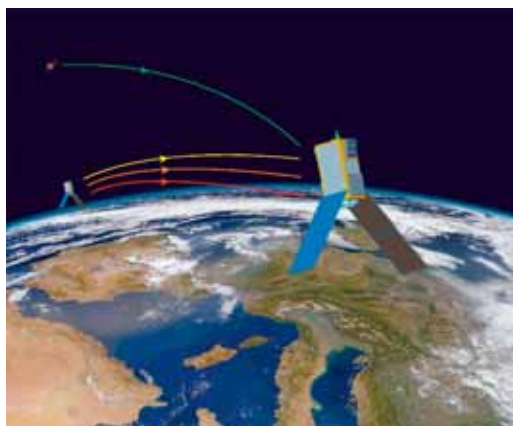
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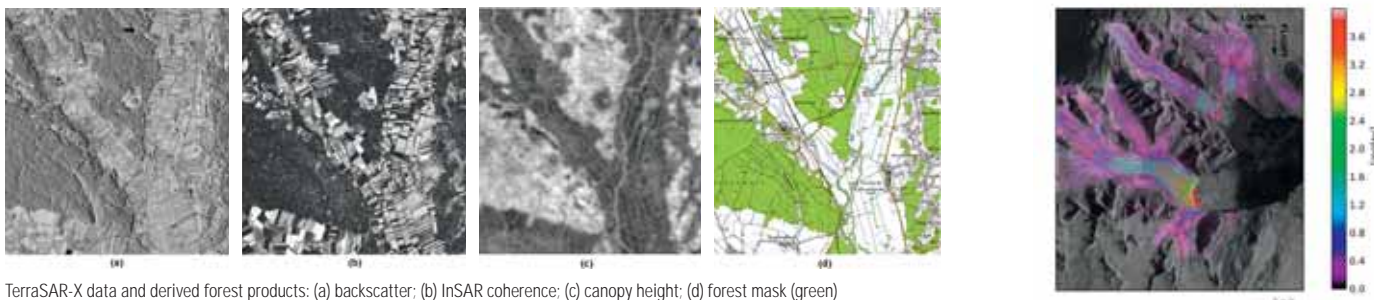


Conceptual artistic depiction of the ACCURATE occultation measurement concept.

© UniGraz 2002

AT-X

Advanced Tools for TerraSAR-X Applications in GMES



TerraSAR-X data and derived forest products: (a) backscatter; (b) InSAR coherence; (c) canopy height; (d) forest mask (green)

The project AT-X was concerned with the development of methods for the operational and scientific utilization of data from TerraSAR-X and other very high resolution spaceborne X-band SAR sensors. It addresses the applications snow and glacier monitoring for water management and climate monitoring and the retrieval of forest parameters. The project work is also relevant for the exploitation of X-band SAR data of the Italian COSMO-SkyMed mission and contributes to preparatory activities for the CoReH2O Ku- and X-band SAR mission presently in Phase-A study at ESA.

The work at ENVEO deals with the development and testing of tools of robust and automated procedures for spatially detailed mapping of the surface motion and deformation of glaciers using TerraSAR-X data. Concepts and software for SAR image correlation and SAR interferometry were developed for generating ice motion maps. The new procedures were validated with in-situ ice motion measurements by means of GPS at the Vatnajökull Icecap in Iceland. Ice motion maps retrieved from TerraSAR-X data stacks were applied to calculate and estimate the ice export and the mass balance of outlet glaciers at the Antarctic Peninsula that are presently subject to rapid downwasting due to global warming.

JR-DIG developed methods for the retrieval of forest parameters (3D canopy height models, forest segmentation and forest border line extraction) from TerraSAR-X data by means of multi-image radargrammetry and segmentation using backscatter, texture descriptors, canopy height model and interferometric coherence information. The achieved accuracies observed in two test sites in Styria outperform state-of-the-art algorithms, while simultaneously providing improved accuracy of forest border delineation.

The project results provide an important basis for strengthening the position of ENVEO and JR-DIG as service providers and consultants for utilization of high resolution SAR satellite data. ENVEO will exploit the developed tools in the Climate Change Initiative Program of ESA and in the downstream service "CryoLand - GMES Service Snow and Land Ice". The CryoLand project under the lead of ENVEO is presently under negotiation.

Ice velocity field of Sjøgren and Boydell glacier, Antarctic Peninsula, derived from TerraSAR-X data of 2008/10/25 to 2008/11/05. Green lines indicate the ice flux gates of the glaciers.

Infobox

Project duration:

1 June 2008 – 31 March 2010

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JR-DIG will exploit the results within EUROLAND, a subproject of the GMES GeoLand-2 project, the ASAP 6 project TripleM and various projects dealing with REDD.

This project was carried out in co-operation with the following international partners:

- > INFOTERRA GmbH, Friedrichshafen, Germany
- > Microwaves and Radar Institute, DLR, Oberpfaffenhofen, Germany
- > Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany

Conceptualization of a Global Virtual Academy for Space-based Information for Disaster Management and Emergency Response

e_SPIDER directly supports the initialization of an e-learning environment for UN-SPIDER by providing a conceptual framework for a Global Virtual Academy for Space-based Information for Disaster Management and Emergency Response. It contributes to the development of an appropriate curriculum in collaboration with the Regional Centres for Space Science and Technology Education, affiliated to the United Nations, and other national and regional centres of excellence to train end-users and strengthen national institutions. The distant learning initiative provides an ideal opportunity to link Austrian expertise to UN-SPIDER and, by this, to a global community.

While the project contributes to the achievement of UN-SPIDER's overall objectives, it is specifically advancing the promotion of e-learning linked to Earth Observation for Disaster Management and Emergency Response. This should help to (i) extend, support and strengthen the educational, scientific & technological background of Disaster Management practitioners and their institutions (ii) initiate inter-regional, multilateral and inter-continental networks among practitioners, and stimulate flows of synergies (iii) through above processes, construct, widen and branch out the paths for mutual exposure to Disaster Management educational systems.

e_SPIDER provides the following results:

- Existing e-learning offers for Earth observation (EO) applications in disaster risk reduction, and emergency response are assessed on a global level.
- An e-learning concept for UN-SPIDER is developed considering the requirements for an international platform (in terms of technical performance and content management); the curriculum responds to the needs of DM practitioners for continuing education and pays particular attention to the provision of near-real-time exercises.
- A monitoring and evaluation concept is established to ascertain the quality of learning modules and exchange of feedback between tutors and participants.



eLearning for practitioners in emergency response and disaster risk reduction

Infobox

Project duration:

1 April 2009 – 28 February 2010

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e_SPIDER Body of knowledge

ENVICHANGE

4D Information Products for the Monitoring of Environmental Changes Based on LiDAR- and Satellitedata

The project ENVICHANGE as proposed here intends i) to identify the possibilities of analysing spatial features for monitoring land cover and essential infrastructure facilities based on high-resolution satellite and LiDAR data and ii) to implement methods for its operational generation. The possibility of fully or partially automated information extraction is evaluated based on user requirements of corresponding federal authorities and infrastructure operators. The essential benefit is considered to be the inclusion of LiDAR derived elevation data, which is a further and inherent information layer besides conventional analysis products, which have been mainly evolved from traditional remote sensing data so far.

The pivotal advantage of the integral, combined interpretation proposed here is that LiDAR as active remote sensing technology precludes drawbacks from shadowing and thus, complements optical satellite data in case of ambiguity. Land cover or infrastructure which could not be interpreted reliably from optical satellite data due to topographical shadows can now clearly be identified and interpreted. The three-dimensional mapping of rock slopes including derived products like rock fall endangered zones or exact location of protective structures are examples for the utilization of data of that kind. The delimitation of forestal areas (protective forests or forest cultivation) or rock slopes as well as the correct positioning of protective structures are in the field of responsibility of the project's user group (Federal State of Vorarlberg, ÖBB Group).

Beneath non recurring analyses the focus is on the multi-temporal evaluation of data of two kinds, satellite and LiDAR data. The recurring combination of the data facilitates the recognition of qualitative as well as quantitative changes. In collaboration with the project user 'Land Vorarlberg' a comprehensively recurring LiDAR dataset is available, which is considered to reveal qualitative and quantitative testimony on changes in river sections, which were affected by the 2005 flooding. Further recurring coverage is to be expected for most parts of Austria in the near future.

The objective of the project is the evaluation of available satellite and LiDAR data with respect to the joined interpretation as well as the development of methods, which render efficient non recurring and recurring analysis products.

Infobox

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1 March 2009 – 30 November 2010

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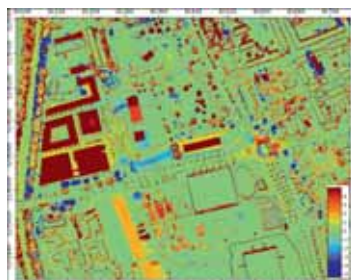
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Innsbruck Tivoli quarter 2006,
ALS altitudes – airplane



Innsbruck Tivoli quarter 2009,
ALS altitudes – helicopter



Innsbruck Tivoli quarter –
urban development
between 2006 and 2009

GEOID+

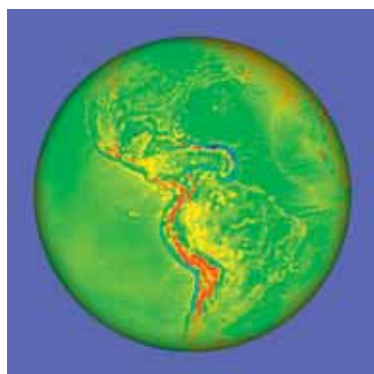
Improved Austrian Geoid Solution Combining Terrestrial and Satellite Gravity Data

The main objective of the project GEOID+ is the computation of an improved geoid model for the Austrian territory, as a combined solution from terrestrial gravity field data (gravity anomalies, deflections of the vertical, direct "geoid" observations being the difference between geometrical heights obtained by high-precision GPS observations and orthometric heights by spirit levelling), and satellite-related data from the dedicated gravity field missions GRACE and GOCE, which shall stabilize the solution in the long to medium wavelength domain.

Compared to the currently available Austrian geoid model, which was computed in the frame of the ASAP Phase 3 project "The Austrian Geoid 2007 (GEOOnAUT)", several enhancements provided new, validated and more accurate terrestrial input data, the incorporation of a global gravity field model based on GOCE data, methodological improvements in the computation process, as well as the opportunity of an independent validation on the basis of the European geoid model.

The precise knowledge of the geoid, representing a physical reference surface and reference level for height systems, is required and applied in civil engineering projects, telecommunication and telematics applications, as well as numerous geoscientific applications. The height determination by the combination of GPS observations and geoid information can replace the elaborate and expensive work of spirit levelling. Also the unification and validation of the national levelling network takes benefit from a high-precision geoid.

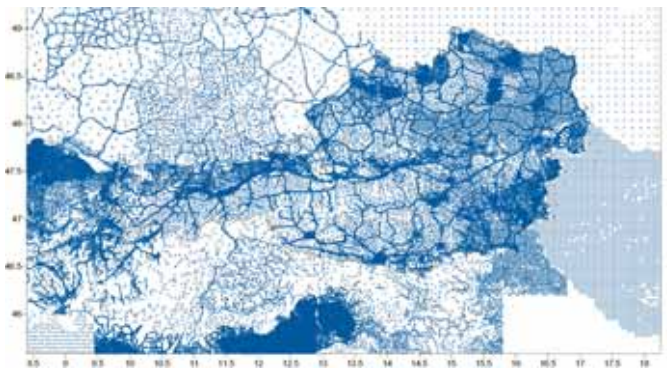
Nowadays, the availability of high-accuracy global satellite gravity models enables to make the local geoid model consistent, also concerning the absolute level, with a global reference frame. The availability of high accuracy global gravity data from satellite missions produced the need to upgrade the formerly used standard processing strategies. Correspondingly, in the frame of this project sophisticated and innovative methods of numerical and computational mathematics shall be investigated and applied to attain this goal.



Approximation of the disturbing potential



Austrian geoid



Gravity data input

Infobox

Project duration:

1 May 2009 – 31 October 2010

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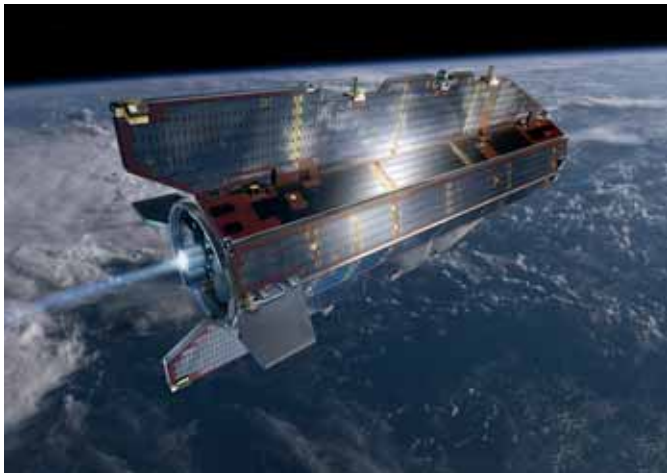
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GOConAUT

Combined High-resolution Global Gravity Field Model from Satellite Gravity Missions GOCE, GRACE and CHAMP, Complemented by Terrestrial Gravity, Altimetry and SLR Data



GOCE in orbit. © ESA – AOES Medialab

The main objective of the project GOConAUT is the generation of high-resolution global gravity field models by combining data from the satellite gravity missions GOCE, GRACE and CHAMP with complementary gravity field information represented by terrestrial and air-borne data, satellite altimetry, and satellite laser ranging.

These different data types are complementary with respect to their measurement principle, accuracy, spatial distribution and resolution, and spectral (error) characteristics. By means of data combination, benefit can be taken from their individual strengths and favourable features, and at the same time specific deficiencies can be reduced, leading finally to global models of the Earth's gravity field with high spatial resolution and accuracy. The models are parameterized in terms of coefficients of a spherical harmonic expansion including a proper error description in terms of a variance/covariance matrix. The data combination of the individual contributions is done on the basis of normal equations. In the frame of a synthetic test environment different challenges and issues of data combination are studied by several numerical simulations. These simulations are to consider theoretical and methodological aspects and to evaluate, e.g., the effect of potential systematic errors, different reference frames and standards, optimum weighting techniques, full or block diagonal normal equation matrices, and regularization issues.

Infobox

Project duration:

1 November 2009 – 31 March 2011

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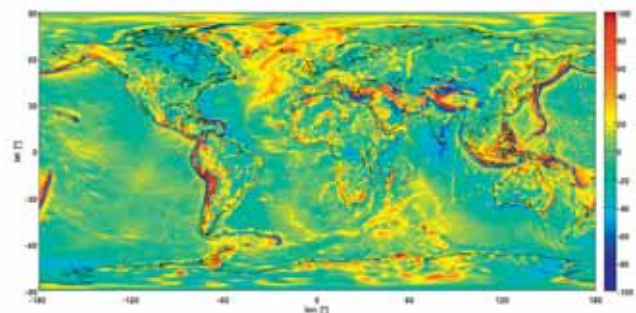
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A high-accuracy and detailed global map of the Earth's gravity field is an important product in many branches of Earth system sciences. In geophysics it is applied to improve the modelling of the Earth's interior and geodynamic processes. In combination with satellite radar altimetry, it improves the accuracy of the models of global ocean circulation, which is responsible for a large part of the global heat and energy transport, and thus plays a crucial role in climate regulation. It also contributes to observing and understanding sea-level change as a result of melting of ice sheets associated with a changing climate. Finally, also geodesy benefits from a unified definition of physical height systems.



Global gravity anomaly map

ICEAGE

Modelling Snow-ice Cover Evolution and Associated Gravitational Effects with GOCE Constraints

In the frame of global warming, various methods for the monitoring of glaciers and ice caps are applied. In this context, the main objective of the project "Modelling snow-ice cover evolution and associated gravitational effects with GOCE constraints (ICEAGE)" was to set-up a processing environment serving to produce a suite of combined cryogravic models of the Eurasian Arctic Sector. Its snow and ice resources (SIR) were determined and mapped with respect to their present state on the one hand and to their fluctuations on the other hand.

This investigation of SIR was performed using terrestrial, space-borne interferometric, altimetric, and gravity field data. Special emphasis was given to estimate the impact and scientific contribution of ESA's satellite gravity gradiometry mission GOCE to regional inland cryospheric studies. By comparing consecutive geometrical models, changes in the cryosphere and its masses are detectable. These variations in ice masses can also be seen in changes of the Earth's gravity field. Thus, a detailed knowledge of the gravity field can deliver valuable information of temporal mass variations in the cryosphere.

In consequence, the Institute of Navigation and Satellite Geodesy, TU Graz, and the Institute of Digital Image Processing, Remote Sensing Group, JOANNEUM RESEARCH Forschungsgesellschaft mbH, investigated cryospheric changes within the non-homogenous gravity field. To obtain the most accurate regional gravity field information, gravity gradients observed by GOCE were used as input data for a least squares collocation process, resulting in gravity anomalies and geoid heights for the test region. These computations were compared to local results of numerical forward modelling, based on a digital terrain model enhanced by vertical density distribution simulations.

As study areas several large European ice caps situated around the Barents Sea, namely the main ice sheet in north Novaya Zemlya, ice domes in north-eastern Svalbard, and ice caps in the central part of Franz Josef Land have been selected.

In the light of climate research the investigation of the cryosphere contributes to a better understanding and forecasting of recent and potential changes of the largest European glaciers, while the improved knowledge of the geoid provides a solid datum for glacier remote sensing and mapping in the study regions.

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Project duration:

1 July 2008 – 30 June 2010

Coordinator:

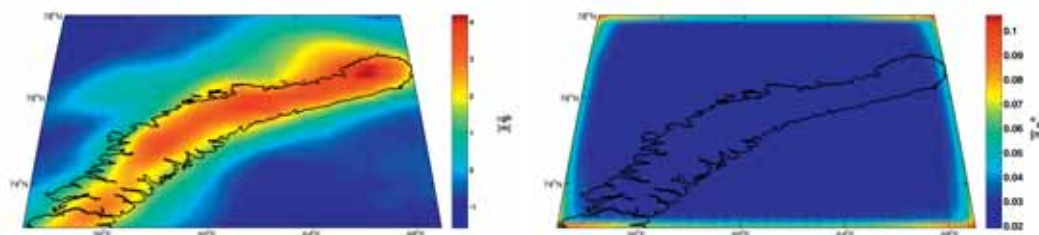
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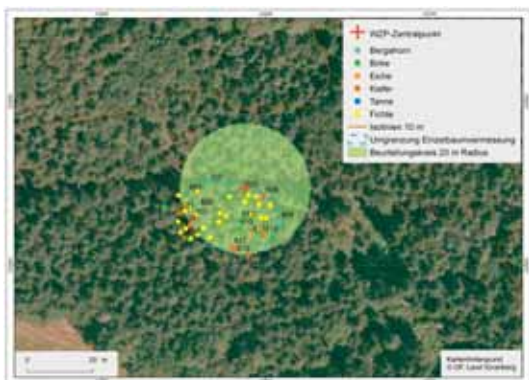
Overview of the study region (source: Marble)



Geoid heights (a) and standard deviations (b) for the Novaya Zemlya area, derived from least squares collocation of gravity anomalies combined with GOCE gradients (simulated from EGM2008 D/O 50 to 2190, resp. 250).

NAVLAS

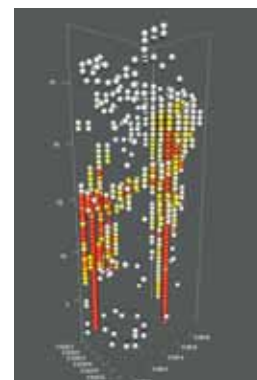
Improved GNSS Positioning Solution via Integration of Information Products from Laserscanning Data



Sample point with terrestrial surveyed trees



3D point cloud from terrestrial LiDAR data



Voxel model from LiDAR data to derive tree height levels and crown density

The project NAVLAS – Improved GNSS positioning solution via integration of information products from laserscanning data aimed to develop digital information layers and software concepts for signal receivers based on the integrating analysis of GNSS-measurements and laserscanning-data. Based on the combined processing of the datasets in the domain of the raw data and derived information products correlation parameters will be extracted. They show the interdependence between vegetation induced shading effects and positioning signal quality.

Related to LiDAR data specific algorithms were developed to derive relevant forest parameters for signal blockage. They aimed at the derivation of information products on the vertical distribution of intercepted forest surfaces, the vertical canopy length and other parameters up to a single tree level and to build the basis for the calculation of a differential forest volume model.

Innovative aspects of the project comprised the adaptation of a LiDAR processing software to airborne and terrestrial LiDAR data. Therefore algorithms were developed, which allow the extraction of forest density and the derivation of further signal blockage and forestry relevant parameters in a test site close to Feldkirch in the province of Vorarlberg.

They comprise:

- Vertical distribution of intercepted forest surfaces
- Crown length
- Topography of the forest ground
- Forest density
- Tree height

These information layers were used to calculate a differential forest volume model based on cuboids of a defined size representing the vegetation density from the ground to the top of the forest.

The combination of the information products based on LiDAR data and GNSS measurements lead to a new knowledge base for the development of GNSS receivers. In particular this comprised:

- A strategy of precise tuned signal acquisition and signal tracking ability for GNSS receivers to improve signal maintenance
- An improved relation between position accuracy and signal availability

With the project NAVLAS a structure and a code independent model of a receiver software was established. Based on the integrated usage of information layers from laserscanning data and GNSS signals this structure can build a programming basis. Receiver developers can use the model for a software implementation of a new generation of GNSS receivers.

Infobox

Project duration:

1 July 2008 – 31 March 2009

Coordinator:

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Pléiades is a French Earth observation satellite program carried out in cooperation with Austria, Belgium, Italy, Spain and Sweden. Pléiades has also the status of a "GMES Contributing Mission". Two Pléiades satellites will be launched in 2011 and 2012 and will offer a spatial resolution at nadir of 0.7 m and a coverage capacity necessary for fine cartography needs, notably in urban regions. The Pléiades product list includes Ortho Images and Ortho Mosaics, which due to their geographic map projections, can be integrated into Geographic Information Systems (GIS).

PAT+ is an innovative software technology for online data access to the Pléiades Ortho Products covering large geographical areas and will be supplied by EOX. A requirements analysis and design study was carried out in previous project phases jointly with the designated Pléiades data distributor, the French company Spot Image. The current status of this development (spring 2010) is that EOX have completed the detailed design and performed the operational readiness review jointly with Spot Image. The available implementation has proven the technical feasibility of PAT+ and the envisaged online data access functions. EOX plans to use the PAT+ system for pre-launch operations starting in 3rd quarter 2011.

PAT+ is uniquely designed in that it combines features for:

- Ingestion of TerraByte-volume ortho products
- Storage in a so-called Coverage Repository (i.e. generation and management of PAT products as aggregated geocoded grid coverages in multi-resolution image pyramids)
- Viewing on the Internet via Web browser providing optimum user experience
- Direct access delivery of PAT products to dedicated client or user application software systems; this includes functionality for back-tracing of product generation history based on meta data
- Identity-centric user access management for implementation of data policy

The PAT+ development enables EOX to continue a long-term international cooperation strategy with the developers of satellite Earth observation interoperability infrastructure and user service systems. The perspective of PAT+ fits into the European initiative for Heterogenous Mission Access and related space standardization efforts, which will be essential for the success of GMES.

Infobox

Project duration:

PAT+ Phase 3: 1 July 2008 – 31 December 2009

Coordinator:

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Pléiades Ortho Image product example for GIS
Copyright 2006 - © CNES



Pléiades Ortho Mosaic product example
Copyright 2006 - © CNES

TripleM

Development of Methods for the Retrieval of Hydrology and Agricultural Parameters from Multi-temporal, Multi-sensoral and Multi-resolution Satellite Remote Sensing Data

Within this project multi-seasonal, multi-sensor and multi-resolution (TripleM) image data sets are investigated with respect to their operational and scientific utilization for agricultural and hydrological applications. The project work is carried out in a joint cooperation between the Institute for Information and Communication Technologies of JOANNEUM RESEARCH Forschungsgesellschaft mbH (JR-DIG) and ENVEO Environmental Earth Observation IT GmbH. Emphasis of the work of JR-DIG is devoted to the retrieval of agricultural parameters such as field boundaries and crop types, while the contribution of ENVEO refers to snow hydrological parameters.

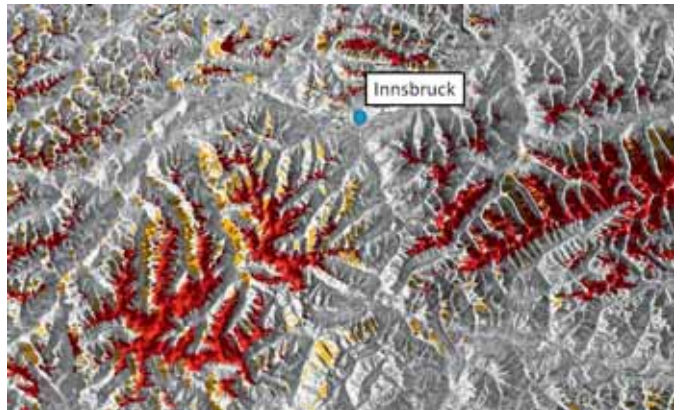
Information extraction is envisaged by simultaneous utilization of a broad variety of satellite image data as indicated above. This is a rather ambitious intention, implying the development of new and innovative approaches to process and utilize TripleM image data sets. Thus, the developments take into consideration the full range of data acquisition capacities of SAR and optical image data and their combination with GIS data. In this context the main emphasis is put onto present and future European SAR systems as well as optical missions, like the German missions TerraSAR-X and RapidEye.

The project results cover improved and validated algorithms and processing lines for:

- Pre-processing of multi-sensor image data, such as matching-based co-registration of satellite data from different sensors
- The retrieval of agricultural parameters, like typical field boundaries and temporal changes of field boundaries
- The retrieval of improved snow extent products for snow hydrology
- Development of concepts for assimilation of spatially detailed snow extent products from satellite data and meteorological data in snow process modelling
- Validating satellite-derived products and testing their applicability, e.g. for updating existing GIS data



The illustration shows first results of matching-based co-registration of a TripleM data set consisting of a radar TerraSAR-X Stripmap MGD image (left) and of an optical RapidEye image (right). The given subscenes have a footprint of 13 x 8 km² at 5 meters ground sampling distance. The cross-modal image matching technique developed within the TripleM project works on a regular grid of points and results in the disparity vectors superimposed on the RapidEye imagery. Using these relative shifts the RapidEye image can be co-registered to the TerraSAR-X image.



Map of snow extent (red) of Western Austria, derived from ENVISAT ASAR Wide Swath Mode data, acquired on 9 July 2006, overlaid on SAR amplitude image. Areas with image layover and foreshortening are shown in yellow.

The achievements of the project will strengthen the activities of the project partners in GMES, in international programmes (ESA) and for value adding services and consultancies in remote sensing. In this respect an advisory/user board is installed for the project, being constituted by industrial as well as scientific partners including Infoterra GmbH, RapidEye AG, Verbund AHP, or the Finish Meteorological Institute.

Infobox

Project duration:

1 September 2009 – 28 February 2011

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GMES in Austria

ASaG

EO-KDZ

G2real

GMES and VIENNA

GMSM

LISA

SAR-X Environ

Preparation for a GMES Downstream Service for Snow and Glacier Monitoring in Alpine Regions

The ASaG project is aimed at the implementation of a satellite-based service for spatially detailed monitoring of snow cover and glaciers over extended areas. Snow cover and glaciers, storing large amounts of fresh water, respond sensitively to climate change. Accurate inventories and monitoring of these resources is important for water resources management, hydrology, and climate impact assessment. The service to be developed in ASaG aims to provide timely and reliable information on the extent and physical properties of snow cover and glaciers, as required for operational use, and shall be exploited in the context of GMES.

The details of the service and products are defined according to identified user requirements. In the initial phase of the project software and processing lines for retrieval of snow covered area from optical and SAR satellite imagery are upgraded in order to optimally match the user needs. In addition, tools for integrating these products in hydrological and meteorological models are being developed. For mountain glaciers a processing line is implemented for satellite-based products on area, vector outlines and glacier zones to be used for updating glacier inventories. The service development builds upon technical know how and processing tools available at ENVEO, developed in previous national (ASAP) and international (ESA and EC FP6) projects. The products comply with the European rules for geospatial information according to the INSPIRE directive in order to ensure interoperability of the data sets. The project and services utilize existing space infrastructure, and shall also enable easy transition to future use of Sentinel satellite data.

In the second project phase snow cover products will be generated in near real time, to be used for initialization and validation of hydrological and meteorological models in pre-operational mode. The glacier products will be generated for major Austrian glacier regions based on new high resolution optical satellite data, in order to update maps of glacier extent. The application demonstration is carried out for several public and private organisations in Austria and Germany.

The project will be exploited by ENVEO within the downstream service "CryoLand – GMES Service Snow and Land Ice". The project under the lead of ENVEO is presently under negotiation in FP7.

This project was carried out in co-operation with the following international partners:

- Norwegian Computing Center, Section for Earth Observation, Oslo, Norway
- Finnish Environment Institute SYKE, Helsinki, Finland

Infobox

Project duration:

1 April 2009 – 31 March 2012

Coordinator:

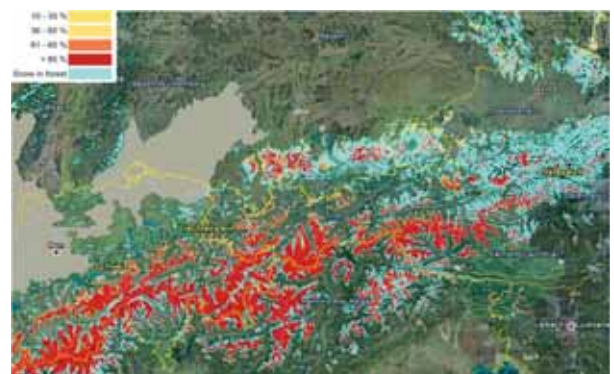
ENVEO Environmental Earth Observation IT GmbH

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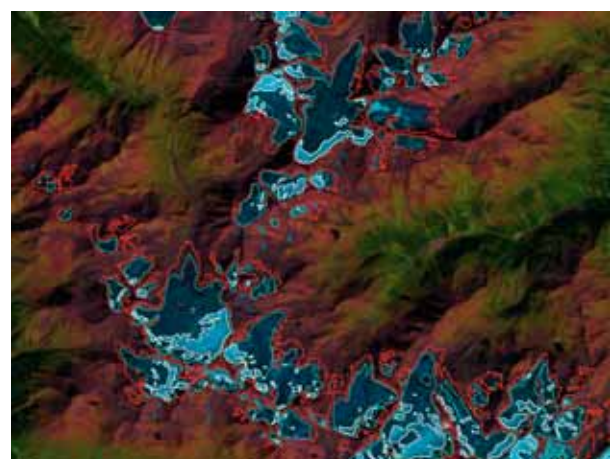
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Map of fractional snow extent (aggregated into 4 classes) derived from Terra MODIS data.



Extent of glaciated areas in Stubaier Alps derived from satellite data: red line - glacier outline 1985; cyan line - glacier outline 2009; white line - late summer snow line 2009.

The dramatic increase of crises caused by natural hazards has created a strong demand for actual and specific geoinformation to enable a co-ordinated management of such events.

In the frame of the project "EO-KDZ" (Earth Observation Krisen-datenzentrum) it was intended to conceptually design and technically implement a regional and Earth observation based centre for crisis data. This mobile centre is characterised by several components of geoinformation, which are collected, analysed and value added near or in the affected areas. The components comprise Earth observation data from instantly submitted programming tasks for rapid analysis, mobile mapping data which are collected in the field for damage assessment as well as available GIS-data (infrastructure, traffic network, ...).

Concerning the Earth observation and mobile mapping components a comprehensive analysis regarding their timely availability and suitability for crisis management, risk assessment and natural hazard monitoring was performed. The technical implementation of the centre for crisis data was conducted via a demonstrator. From the hardware side the centre consists of several computers and mobile units in form of Personal Digital Assistants (PDAs), which are made available in case of activation. The mobile units calculate their position and time by means of satellite navigation in combination with autonomous sensors. They are equipped with the relevant and specific image processing, data management and GIS software. The field-collected data is transmitted to ERDAS TITAN, which serves as a system for data exchange and communication. Finally, ERDAS APOLLO, an OGC compliant data management system, is used to organize the huge amount of data. For demonstration purposes, data of the flooding in August 2005 in Austria and of the earthquake in May 2006 in Yogyakarta, Java/Indonesia, was implemented and analysed. The derived information products were validated in collaboration with the end user regarding their effectiveness and accuracy. Further on, compatibility of the products with international centres for crisis information (e.g. of the German Remote Sensing Data Centre) was ensured to make use of data acquired in the frame of the International Charter "Space and Major Disasters" as well.

Infobox

Project duration:

1 March 2007 – 31 May 2009 (2 phases)

Coordinator:

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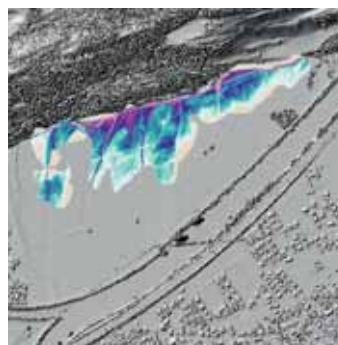
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(www.alps-gmbh.com)
Universitätszentrum Rottenmann (www.uzr.at)
University of Innsbruck, Institute of Geography
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Users:

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Tyrolean Regional Hazard Warning Centre
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Surveying Agency of the State of Vorarlberg
(Landesvermessungsamt Feldkirch)
State Warning, Disaster and Relief Management Centre
Vorarlberg (Landeswarnzentrale Vorarlberg)
United Nations Platform for Space-based Information for
Disaster Management and Emergency Response (UN-
SPIDER)

Water depth at the test location "Kramsach",
derived via RADAR classification and LIDAR digital
elevation model.

Tiefen der Überflutungsflächen



G2real

Galileo-based GMES Real-time Emergency Support Testbed, Real-time Exercise and Development of Services

The overall aim of G2real is to develop and test new preoperational GMES services in the field of emergency and disaster management and rescue operations by integrating software and hardware solutions developed by 11 partners in three countries (AUT, GER, ES) and by testing and utilising the possibilities of Galileo navigation.

Real-time emergency-response support

Key requirements for real-time decision support in disaster management are high quality, accuracy and especially topicality of the underlying information layers. While the accuracy and completeness of base data have been quality criteria in traditional GIS applications for many years, the topicality parameter has only very recently received attention through the rapid emergences of a variety of real-time data sources (e.g. sensor networks, georeferenced cameras, RFID-based systems etc.) enabling situational awareness in real-time.

However, heterogeneity in sensor network systems and proprietary system design mostly limit interoperability and flexibility, and thus hardly support the creation of transnational Common Operational Picture (COP) involving multiple data sources provided by a variety of authorities from different organizations and countries.

G2real focuses on the integration of real-time Earth observation data and in-situ (terrestrial) sensor measurements leveraging existing and emerging Open-Geospatial-Consortium (OGC) standards to support first responders in the disaster mitigation and response phase. At present most technical emergency solutions lack integration capabilities due to the broad usage of proprietary and closed system solutions. Thus the project consortium is chaining existing software components and technologies (developed in various projects like RTGA, GENESIS, LIMES etc.) creating a real-time emergency-response thematic service bus interconnecting EO and location enabled real-time in-situ sensor measurements utilizing OGC and ISO standards for supporting first responders.

Galileo field exercises

Additionally, the challenges and advantages using new Galileo positioning technology have been assessed in a Galileo field test in the Berchtesgaden GATE-test bed region. The integration of standardized real-time radiation measurements (based on OGC Sensor Web Enablement) have been performed in a field test in Seibersdorf, Lower Austria. The results of these field tests are now combined, validated and reviewed concerning market and application potential and provide base information for the G2real simulation components.

Infobox

Project duration:

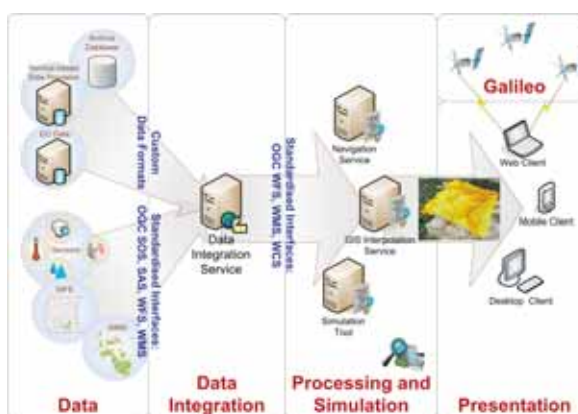
1 November 2009 – 1 January 2011

Coordinator:

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G2real concept



G2real workflow

GMES and VIENNA

City of VIENNA – a “GMES-USER” and/or “GMES-PROVIDER”?



Recreation and modern city development. © TINA VIENNA

The project analysed to what degree individual municipal departments could take the role of a “GMES-USER” or a “GMES-PROVIDER” and how such a role could efficiently support them in fulfilling their tasks. This was an explorative undertaking, focussing on the GMES Domain Land. It included information gathering, joint learning, technical analyses and a systematic screening of municipal tasks.

The City of Vienna fosters innovation by following a systematic approach

In order to foster innovation it is important to identify the potential of new technologies as early as possible and to follow a systematic approach. Therefore a systematic check of possible uses of GMES products and also of costs and efforts of such applications has to be considered.

The objective of the project “GMES and Vienna” was to identify potential applications of GMES in all areas of the city administration.

The objectives of the project were:

- To raise the level of awareness for potential applications of GMES
- To identify tasks where GMES products could possibly be of use and to deliver a differentiated evaluation concerning potential applications of GMES
- To specify which steps should be taken next

More than 10 different departments out of the following areas were integrated into this project:

- Emergency / Security
- Statistics (“socioeconomic data”)
- Information technology (Geographic Information System)
- City planning
- Environment (protected areas, waste deposit monitoring, green areas)
- Climate and energy (emissions, renewable energy, energy efficiency)
- EU-Strategy (EU-Commission: strategy for the Danube Region)

Infobox

Project duration:

1 February 2009 – 31 May 2010

Coordinator:

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- Infrastructure (power plants, grid infrastructure, energy provision)
- Surveying and Mapping

Results

Results of the project “GMES and Vienna” are the following:

- The expectation was fulfilled that GMES products can be applied in a number of areas.
- At the same time the use of applications has still to be defined more explicitly and clearly. Once the use of an application is transparent, the necessary fundings have to be calculated.
- All departments involved are now well aware of the content and scope of GMES.

Further activities cover a broad range from “observing developments in the GMES world” up to “preparations of potential pilot projects” for example in the area of forestry or air quality forecast.



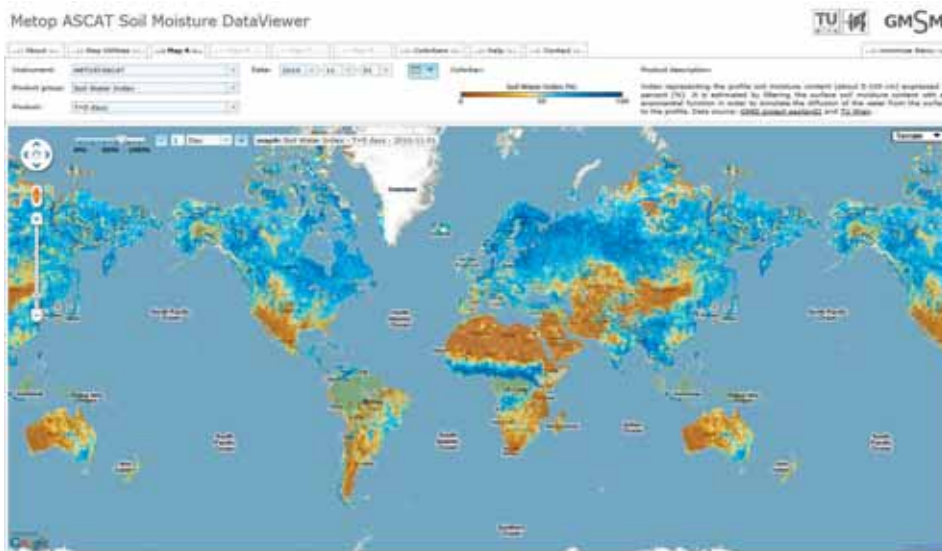
GMSM

Global Monitoring of Soil Moisture for Water Hazards Assessment

Soil moisture – the water stored in soil within reach of the plants – is a crucial parameter for a large number of applications. Near-real-time soil moisture information is, amongst others, important for weather forecasting, flood and drought monitoring, and civil protection. Long-term soil moisture time series are important for improving our understanding of impacts of global warming on water resources, carbon balance, ecology and epidemiology.

The overall goal of the GMSM project is to advance the use of soil moisture services based on METOP ASCAT and complementary satellite systems, most importantly SMOS and ENVISAT ASAR, by extending existing products developed at I.P.F. TU Vienna to Africa and Australia, for which extensive calibration and validation activities will be carried out and novel water hazards applications will be developed by the project consortium.

Water hazards, as understood here, arise due to the excess or lack of water and harm society in multiple ways. Excessive rainfall and/or rapid snowmelt may quickly saturate the soil in a catchment area, leading to water logging, surface runoff and flooding. If sustained for longer periods, water excess may affect plant growth and lead to the proliferation of water-borne diseases. A prolonged lack of rainfall depletes the soil water reservoir leading to drought conditions which may affect the productivity of agricultural areas and natural ecosystems, limit the availability of fresh water for humans and industry, and increase the risk of fires. Multi-year droughts may lead to land degradation and desertification.



Browser based soil moisture product visualizer available at <http://www.ipf.tuwien.ac.at/radar/dv/ascats>.

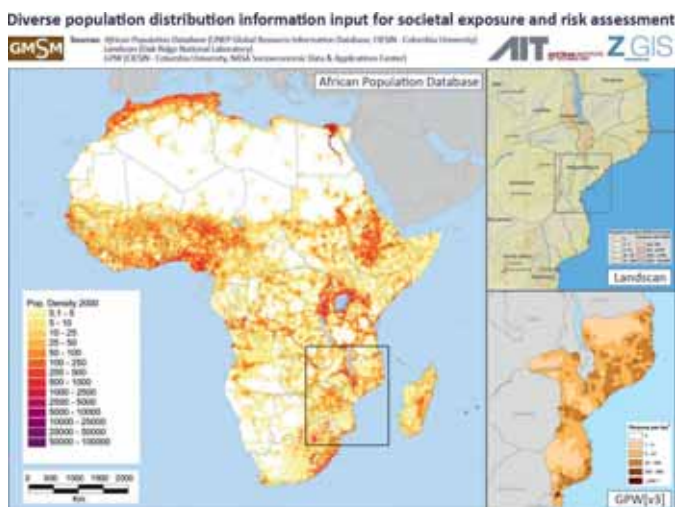
To promote the use of the remotely sensed soil moisture products and to gain attention among potential users, a data visualizer run in an internet browser was implemented. This data viewer gives the possibility to map different soil moisture products, namely surface soil moisture (SSM), or soil water index (SWI), as an indicator of the profile soil moisture and their anomalies, at different zoom levels. The basis for this visualizer is based upon the freely available web service "Google Maps". This provides the possibility to explore spatial patterns and compare them to map data and optical satellite data.



Within the GSM project the following application-oriented topics will be addressed:

- Assimilation of ASCAT soil moisture data in a regional numerical weather prediction (NWP) model
- Improve regional scale crop growth and yield monitoring methods
- Improve hydrologic model predictions
- Modelling the dynamics of mosquito-borne infectious diseases
- Validate the land surface module of regional climate models
- Improve methods for desertification monitoring
- Integration with population data for improved determination of societal risks

The project complements existing European GMES-related programmes, most importantly EUMETSAT's Product Processing Facility, the Hydrology SAF, the GMES project GEOLAND II, and ESA TIGER Activities.



Soil moisture will be integrated with population data for societal risk assessment

Water hazard assessment consists of the determination and monitoring of certain environmental conditions and is also strongly related to impacts on population, infrastructure and activities. Human exposure to hazards is a key factor for turning mere natural events to natural disasters.

Various population data sets based on different distribution modelling concepts are hence used to determine vulnerable areas and are spatially correlated with physical parameters such as land cover and particularly soil moisture information (i.e. hazard probability analysis) for general risk assessment. Investigations will be carried out to evaluate potential implementations of early warning concepts driven by soil moisture information.

Infobox

Project duration:

1 April 2009 – 31 December 2010 (Phase 1)

Coordinator:

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LISA

Land Information System Austria



LISA – Land Information System Austria. © GeoVille

Europe in general and Austria in particular can rely on a long experience of successful activities on land cover and land use monitoring. However, these datasets were produced with different standards, lack comparability and are in most cases outdated. The new European directives and national legislation demand up-to-date, more detailed, harmonised information on regional and local level, in order to fulfil the required reporting obligations.

Therefore, the availability of a homogenous land cover and land use (LC/LU) dataset is an indispensable public necessity, needed for political decisions, effective administration, successful corporate governance and personal usage of the citizens. In particular such geo-information is required by departments of public administration at state and federal level for the interests of regional planning, forestry and agriculture, water management, natural hazard management, environmental and nature conservation for the periodic monitoring of changes. Detailed data on land cover are also required in the private sector such as site planning and geomarketing to name but a few. The land cover data currently available do no longer meet these requirements either because of their low resolution or because of their heterogeneous topicality.

In order to overcome the shortcomings of the existing LC/ LU data sets for regional, national as well as European management and reporting requirements, the project Land Information System Austria (LISA) was initiated.

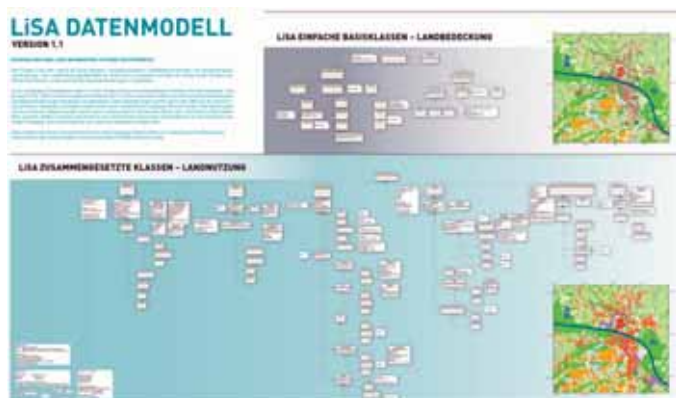
The objective of LISA is to achieve a consensus on a new Austrian land cover data base and demonstrate its benefits offering improved spatial and thematic content. A first prototype, which was specified by the users consisting of relevant experts from all regional governments as well as from federal authorities and institutions, was already put into effect for a large number of test sites in Austria. Based on the scientifically validated results of the prototype the users adapted the specifications to achieve a technologically and economically feasible datamodel for national rollout.

LISA is designed to serve common land monitoring needs providing information on the status quo and the changes occurring in Austria's landscape. Thereby LISA will enable a wide range of downstream sectoral applications for various user groups (LISA = multi-purpose/multi-usage).

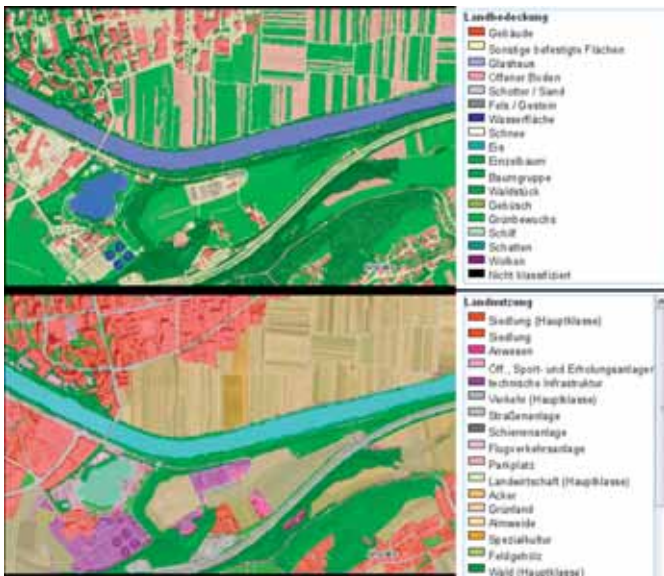
The goal of LISA is to apply cutting edge science, innovative technology and provide cost efficiency by combining satellite with high resolution in-situ data, to achieve economics of scale and sustainability of funding through a shared effort across different administration units.

LISA is conceived to build upon the preferred access of Austria to Pleiades satellite data as well as existing data in user organisations, such as orthophotos and airborne laser scanner data. A successor project under ASAP 7, namely LISA II, will complete the monitoring aspect and develop specialized downstream applications.

For more information on the status of the Land Information System Austria please refer to www.landinformationsystem.at.



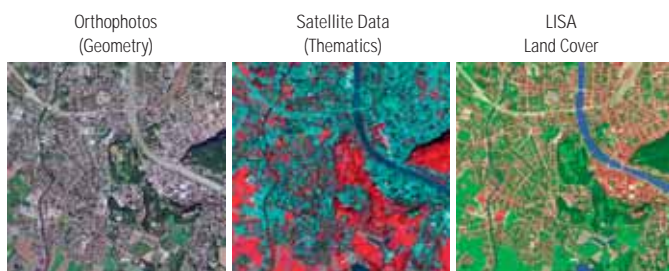
LISA datamodel. © GeoVille



LISA land cover (top) and landuse (bottom) prototype. © GeoVille



LISA Geoportal. © GeoVille



Production of LISA land cover (right) from earth observation data

Infobox

1 May 2009 – 31 October 2010 for Phase 1

Coordinator:

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SAR-X Environ

Environmental Mapping Applications Using TerraSAR-X



Aerial imagery (left), TerraSAR-X Spotlight data (second left), Digital surface model (second right) and automatically generated SAR-X Environ forest species map layer (right).

© TU Vienna, GeoVille

Remote sensing has become an operational tool in many areas for environmental mapping applications. Main focus so far has been on the use of optical sensors having a strong drawback due to their dependency on cloud coverage. With upcoming commercial radar sensors, research activities revealed a strong potential of radar data for environmental mapping activities. Nevertheless, their use has been restricted due to low resolution. With the launch of TerraSAR-X in 2007, new SAR data have become available, offering high resolution (up to 1 m) and fully polarimetric data for sophisticated mapping applications. Nevertheless, little is yet known about the information content and application potential in environmental land applications.

Therefore, the goals of this project were

- The improvement of existing X-band scattering models and
- The development of environmental mapping applications for TerraSAR X data in Austria and in potential export markets

Development was performed in co-operation with stakeholders on the user side, comprising the Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW) in Austria and the Central American Commission for Environment and Development (CCAD) in El Salvador. Experience in research and space science, applied research as well as commercial implementation and application development are the complementary SAR-X Environ project partner assets.

The results of SAR-X Environ comprised assessments of the functional interdependence between surface parameters like surface/terrain roughness and volume scattering of different vegetation types and TerraSAR-X backscattering information. The project aimed to develop new forest classification approaches with respect to extent, tree species and structural forest parameters using a combination of TerraSAR-X data together with optical EO data (satellite data and orthophotos) and ALS derived surface and terrain roughness layers. In addition, a land cover change mapping (1999-2008) in Honduras with specific focus on deforestation/afforestation and forest degradation was performed. In the course of this work a state-of-the-art forest module allowing interoperability with several GI processing environments, was developed for increasing processing efficiency.

Infobox

Project duration:

1 January 2008 – 1 June 2009

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Second, a methodology for the derivation of a terrain roughness map was developed and tested within the specified test areas in Austria. Results of the roughness classification were crossvalidated with the Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW). A high level of thematic accuracy and a high service level prospect for use in different application domains were achieved.

Finally, the methodologies for the derivation of forest extent, forest type and forest parameter maps generated with SAR and optical data and applied in test areas in Austria and Middle America proved to be highly automated and transferrable to other areas. In the test site Yoro/Honduras it revealed that forest cover change rates exhibit a significant dependence on the management type and this could subsequently be demonstrated in a large area roll-out financed by the World Bank.



Automatically generated SAR-X Environ forest species map layer for "Bucklige Welt", Lower Austria.

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Navigation

GNSSMET-AUSTRIA

I-Game 2

IMUVar – GRAVIS

IMUVar – VarloNav

INSIDE

MGM – Mobile Geo Memory (Feasibility Study)

NAV-CAR Feasibility Study

NAV-CAR2

NAVWAT

OEGNOS

OEGNOS 2

RA-PPP

SoftGNSS 2

GNSSMET-AUSTRIA

GNSS based determination of atmospheric humidity changes and their assimilation into operational weather forecast systems

The distribution of Water Vapour within the lower atmosphere is a determining factor of the weather conditions and therefore plays an essential role within short-term forecast models but also for long term climate studies. Unfortunately, this distribution is usually not very well known or understood with acceptable high temporal and spatial resolution.

The microwave signals of the GNSS satellites (GPS, GLONASS and in future GALILEO) are time delayed when passing the atmosphere. Therefore the tropospheric delay (as part of the atmospheric delay) and subsequently the humidity distribution within the troposphere can be estimated from the microwave observations. The tropospheric delay is usually comprised of a well understood hydrostatic component and of the rapidly time varying wet component. The remaining wet component can be assimilated in numerical weather models. It has been proved that e.g. passing weather fronts can better be analysed by introduced GNSS derived tropospheric wet delays because this data is influenced by changes in humidity in the free atmosphere, whereas the data at the meteorological ground stations reacts to these changes only with a time delay. This allows to forecast heavy rainfall causing potentially local floodings more reliably and to narrow down the affected region. To contribute efficiently to weather forecast the water vapour content has to be known within a delay of less than one hour. This demand is hard to fulfil because of data transfer delays and considerable processing times due to the huge amount of GNSS observation data.

In the framework of project GNSSMET AUSTRIA the wet part of the tropospheric delay is estimated with a temporal resolution of one hour and an accuracy of better than +/- 1mm PW based on observations of a GNSS reference network covering more than 30 stations distributed over the whole Austrian territory. These values are assimilated within the ALADIN-Austria model operated at the Central Institute for Meteorology and Geodynamics (ZAMG). New modelling schemes to derive the signal delay are examined. This concerns the derivation of wet delays by means of a mixed network and PPP (Precise Point Positioning) approach as well as the implementation of new mapping functions like the GMF. Last but not least the direct signal delay along the ray path shall be used to establish a 3D-model of refractivity (GNSS tomography).



Infobox

Project duration:

1 June 2009 – 31 October 2010

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GNSS stations network

I-Game 2

Development of an Integrated Telemetry System for Game Management in Matters of Traffic Security, Protection Forest and Private Forest Based on Navigation, Communication, Remote Sensing and GIS Methods – Phase 2

Current wildlife telemetry systems by means of bearing transmitters have the disadvantage to disturb the animal's behaviour and to be time-consuming. Newly developed systems based on GPS and GSM technology actually have a relatively low data rate due to a restricted energy supply. Therefore, a telemetry system based on GPS and GSM technology has been developed which allows a generally higher data rate due to additional energy generation on the animal. Furthermore, it enables the flexible adjustment of the data rate to external conditions such as weather and actual whereabouts of the animal. A camera mounted on the telemetry collar provides additional significant information on the animal's behaviour.

An initial feasibility study has shown that in principle the proposed long-term wildlife monitoring system is practicable. The second phase of the project was dedicated to the detailed specification and configuration of the telemetry system up to a beta-test.

User requirements concerning the features of the telemetry collar as well as the GIS analysis of the acquired data were transformed to technical user specifications in order to integrate appropriate hardware and software components.

Extensive testing comprised the energy consumption of each single hardware component, as it is a crucial factor of the telemetry system. Especially the necessary settings for the GPS device were investigated in detail with a series of start-up tests. Energy application of flexible solar panels mounted on the telemetry collar has been determined in a fence test. Based on the outcome of these analyses the final system layout was established. Three telemetry collars were manufactured and mounted on red deer for a long-term beta test.

Concurrently, a GIS system was designed in order to analyse the data acquired as well as to visualise the results achieved. It is realised in a web GIS application which may be operated in any internet browser with appropriate access information.

Innovative aspects, like power supply by solar panels and fuzzy or interactive adjusting of the system present a major improvement to common telemetry systems and thus meet the requirements of the users.



Telemetry test collar with solar panel and GPS antenna

Infobox

Project duration:

1 June 2008 – 31 December 2010

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Location of game anaesthetisation and one game GPS position

IMUVar – GRAVIS

Terrestrial Moving-Base Gravimetry Using a GNSS/SINS Platform



Platform

One method for the determination of the regional gravity field is the use of airborne gravity mapping systems. Today receivers based on Global Navigation Satellite Systems (GNSS) and strapdown inertial systems (SINS), mounted on a multi-sensor platform are used.

The GNSS/SINS combination may be adapted for terrestrial use where the platform will be mounted on a car. The gravity measurement by a moving car is a possible alternative to airborne and terrestrial gravimetry. This method can especially be applied for the densification of gravity measurements in complicated regions with sparse gravity distribution. Within the project GRAVIS a demonstrator for determining the Earth's gravity field by using a car will be built.

One task of the project is the stable determination of accelerations from GNSS measurements, which can be influenced by the difficult surrounding in the case of terrestrial applications like cycle slips, multipath and shadowing effects. Another critical task is the error analysis of the terrestrial application which will need a more complex discussion of the error terms compared to the airborne case. In principle, the error of the gravity vector for the strapdown inertial gravimetry is mainly a function of the attitude errors due to the initial misalignment and gyro measurement noise, the accelerometer noise, errors of the determination of the vehicle acceleration by GNSS and a synchronization error between the SINS and GNSS system. The SINS uses ringlaser gyros and servo accelerometers.

Infobox

Project duration:

1 January 2009 – 30 September 2010

Coordinator:

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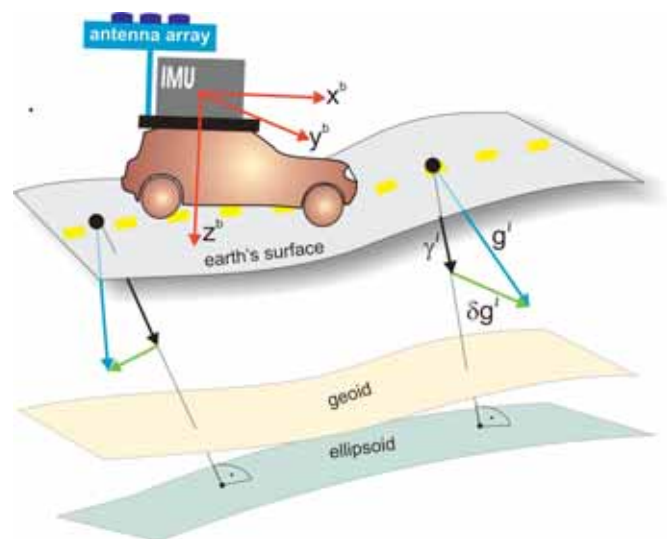
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An innovative approach is the concept of using an antenna array to support the gyro measurements in order to compensate the gyro readings for the drift behavior. The concept of the GNSS/SINS combination is based on the fundamental equation. There the specific force measured by the accelerometers of the SINS is the difference between the inertial acceleration of the vehicle and the gravitational acceleration. That means if the inertial acceleration of the vehicle can be determined with GNSS, the gravity can be directly obtained. The task of GNSS is the determination of the vehicle's acceleration as well as the vehicle's velocity and position. In principle, a double differentiation of the position is needed. Errors of the vehicle acceleration are directly proportional to the gravity error.



Gravity determination

IMUVar – VarloNav

Analysis of Various Integration Methods of GNSS and Inertial Measurement Systems with Respect to Different Scenarios of Georeferencing

The main objective of the project VarloNav is a scientifically based and comprehensive investigation of the integration of Global Navigation Satellite Systems (GNSS) and inertial measurement systems (IMS). Regarding the high value of GNSS/IMS fusion within integrated navigation, the integration analysis is performed against the background of the challenging trajectory determination for a mobile exploration system (e.g., imaging sensors) and the subsequent direct georeferencing of the sensor and its output.

In the field of navigation, integrated navigation is an upcoming technique. This means that trajectory determination of a moving object is performed via sensor fusion. Sensors with different operation principles and characteristics complement each other in such a way that disadvantages of the one sensor are compensated by advantages of the other and vice versa.

In the case of mobile platforms (terrestrial or airborne), the integration of satellite-based positioning and inertial measurement systems is gaining in importance today. GNSS, such as GPS or the future Galileo, represent absolute positioning (absolute coordinates of long-term accuracy), but in the sense of radio navigation, they are non-autonomous systems. In contrast, inertial navigation (use of gyroscopes and accelerometers) is self-contained, but is indicative of relative positioning (small coordinate differences of short-term accuracy). Therefore, the importance of such a sensor integration is obvious: an inertial measurement system overcomes shadowing effects of GNSS, while GNSS compensates the IMS-typical drift behaviour.

Within the scope of the project VarloNav, a science-based and comprehensive investigation of diverse types of GNSS/IMS integration is performed. For this purpose, GNSS receivers and inertial measurement units (IMU) of three different quality and price classes (low, middle, and high) are to be compared in a lot of possible combinations. The type of integration not only depends on the quality of the involved sensors but also on the coupling method within signal processing. Due to the used filtering technique, an uncoupled, loosely coupled, and tightly coupled integration of GNSS receivers and IMUs can be performed.

As a primary result of the investigations, a classification of the integration types with respect to usability, accuracy, and reliability is expected. The two latter quality measures are related to positioning and attitude determination. For the purpose of direct georeferencing, the methods of GNSS/IMS integration are based both on simulations and experimental tests for measurement and imaging platforms.

Infobox

Project duration:

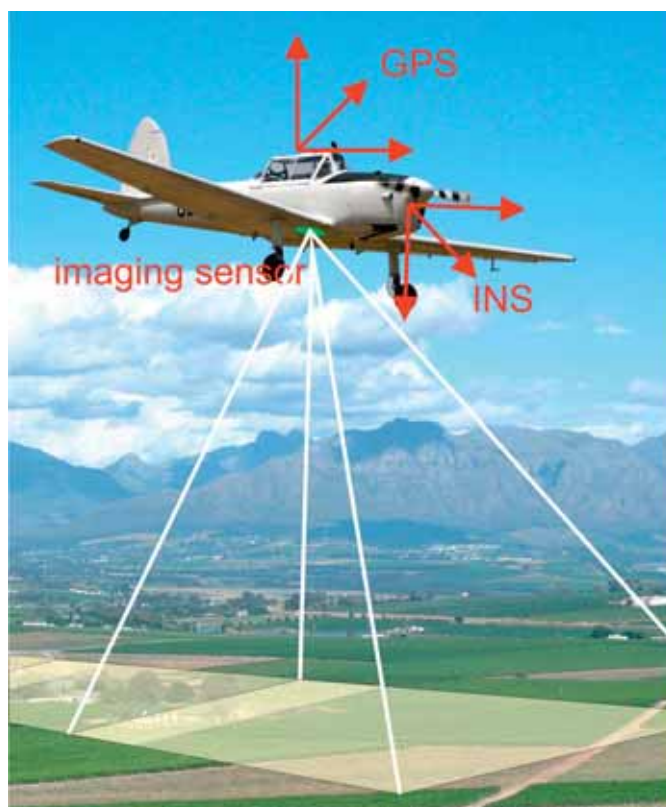
1 March 2009 – 30 September 2010

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Digital Image Processing

INSIDE

Integrated Safety Critical DGNSS Service

The Austrian Alps are famous for hiking in summer and skiing in winter. In the tight competition of ski resorts, perfect ski slopes are a key factor for economic success.

The preparation process is done mainly during the night time for safety reason. If the weather is snowy, foggy and windy, orientation in the difficult area is very hard due to poor visibility. Consequently, on the one hand, outages in the preparation decrease the quality of the ski slopes and therefore the acceptance by skiers. On the other hand, overlapping increases costs for fuel, time and equipment. Beside these monetary effects, drivers of snow groomers cannot see topographically dangerous areas, such as steep gradients, in bad weather situations.

The aim of INSIDE is the development of a first demonstrator of a GNSS based information system to support drivers of snow groomers. The snow groomers will be equipped with a GNSS receiver and an automotive computer as central processing device. The touch screen displays the actual position and the infrastructure and dangerous areas on a digital map as background. Furthermore, tracks of already prepared slopes will be highlighted to avoid multiple preparation work. During the preparation process, the trajectories and vehicle date of snow groomers are recorded. After work, the data is transferred by a WLAN connection to a central server. This documentation of driving can finally be used for employee payment and optimization of trajectories and preparation work.



Touchscreen snow groomer

Infobox

Project duration:

1 March 2009 – 31 December 2009

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Beside this complete vehicle management, the GNSS positioning of snow groomers is monitored by a sophisticated software module. The software generates status information from EGNOS and EDAS data as well as from actual measurements from GNSS receivers in the application area. Based on these integrated data, augmentation data are calculated and broadcasted to the snow groomers in action. In case of system discrepancies or positioning problems, the driver immediately gets a message on the screen in the vehicle telling him that the system must not be used for safe navigation.

By the use of the INSIDE demonstrator, the comfort and safety of slope preparation can be increased. Further developments and enhancements are in progress and will support ski resorts by an innovative system to be competitive in winter sport tourism.

NAV-CAR Feasibility Study

Feasibility Study: Improved Navigation in Challenging Areas by Robust Positioning

The feasibility study for NAV-CAR focussed on the potential benefits for the services to be facilitated by the availability of high-quality, high precision positioning data allowing lane-specific services. NAV-CAR is based on results of the EU Integrated Project COOPERS (FP6-2004-IST-4, grant agreement 026814) and leads beyond COOPERS with respect to high accuracy and lane-specific positioning and navigation.

Motivation for the project

Robust, lane sensitive car navigation will be an important contribution to road safety and traffic management. Currently there is no system that can provide the necessary lane specific information since positioning by navigational satellite is not accurate enough and the necessary map data for map-referencing are not available either. For this reason NAV-CAR addresses the

- Improvement of positional information as well as
- Development of a lane specific map prepared for high precision geo referencing

By combining existing technologies of in-car navigation and in-car sensors with new algorithms for data fusion, NAV-CAR makes an important contribution to the development of robust, high precision positioning. With the experience gained in this project, Austria can start to play a major role in this field, bringing benefit both to research and industry.

Examples of benefits of lane-specific high accuracy positioning (beyond COOPERS):

- In mountain areas and in tunnels with high traffic density where satellite based navigation is not guaranteed, being a safety risk for road users and maintenance staff, safety and service availability will be improved.
- Improved traffic management by precise local speed profiles: Locating events on the road on a specific lane and hereby reducing the disturbing effects of that event for the other road users, facilitates e.g. to keep an unaffected lane open to vehicles to pass at a reduced speed.
- In case of heavy traffic or critical situations, the road operator can re-direct lane traffic to emergency lanes or exits/entries via the onboard unit.

In the feasibility study, the NAV-CAR value chain was developed describing the stakeholders involved and the benefits gained from NAV-CAR services (see figure). The study resulted in a considerably improved proposal for NAV-CAR development, which was finally accepted by the ASAP Program (NAV-CAR2 project).

Infobox

Project duration:

1 August 2008 – 31 December 2008

Coordinator:

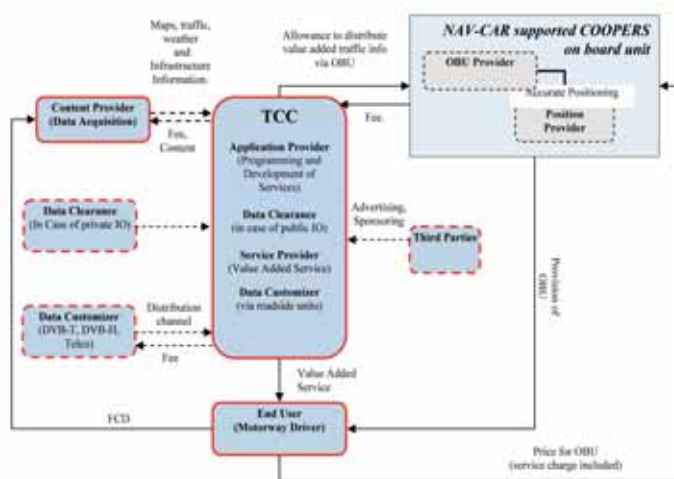
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Value chain for safety critical services on the highway

NAV-CAR 2

Improved Navigation in Challenging Areas by Robust Positioning

NAV-CAR 2 is a national research project, co-financed by the Austrian Federal Ministry for Transport, Innovation and Technology within the 6th call of ASAP (Austrian Space Applications Programme).

NAV-CAR 2 aims at making car navigation more robust while at the same time providing more accurate and precise information compared to existing navigation solutions.

The focus lies on more accurate robust positioning and map referencing in order to be able to provide lane specific positioning information for traffic and navigation information services.

Challenges

Current satellite based vehicle information, navigation and tolling systems rely on a minimum number of satellites that are both visible and well distributed to compute geo-reference data at the accuracy promised by the operators. Nevertheless, specific environments such as urban canyons, woodlands and mountainous regions very often do not fulfill the requirements for a continuous and reliable satellite connection of the navigation system leading either to wrong positional data or no data at all.

Solution

Positional information from navigational satellites is augmented by data collected using an in-car sensor network and combined with high precision map data. This in-vehicle process will not only allow the correction of the signal provided by the navigation satellites but also to substitute missing signals, which may occur in tunnels, urban canyons and mountainous areas.

NAV-CAR 2

builds on experiences made in the European IST-project COOPERS (www.coopers-ip.eu) and the know-how of pwp-systems in the field of high-precision car navigation and simulation. Within NAV-CAR 2 this know-how is used and enlarged especially in the realm of sensor data fusion and map referencing.

Innovation

The innovative part of NAV-CAR 2 is the data fusion of navigational and in-car-sensor data to provide robust, accurate and precise positioning information. In combination with precise map data, which will be generated in the course of NAV-CAR 2 for the proposed test sites (urban motorway Vienna, Brenner motorway), lane sensitive navigation and information will be demonstrated. In-car data (e.g. from CAN-bus) are used to calculate a delta position from the last measured satellite positioning signal. The main problem to be resolved is to find suitable interfaces for data fusion and to utilize all available sources of information in an innovative manner.

Infobox

Project duration:

1 July 2009 – 30 April 2011

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NAV-CAR overview: urban and Alpine scenarios for improved high accuracy positioning.

NAWWAT

Future High Precision Navigation System for Inland Waterways



Infobox

Project duration:

1 April 2009 – 31 March 2010

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In NAWWAT, a system concept was developed which aims at supporting the ship crew of inland water vessels when navigating through narrow surroundings (in the vicinity of locks, bridges, harbours). The proposed concept utilizes modern GNSS and augmentation infrastructure to provide accurate position and velocity information as well as integrity information to the ship crew. This precise position information should be related to the information contained in the onboard Inland ENC (Electronic Navigational Chart).

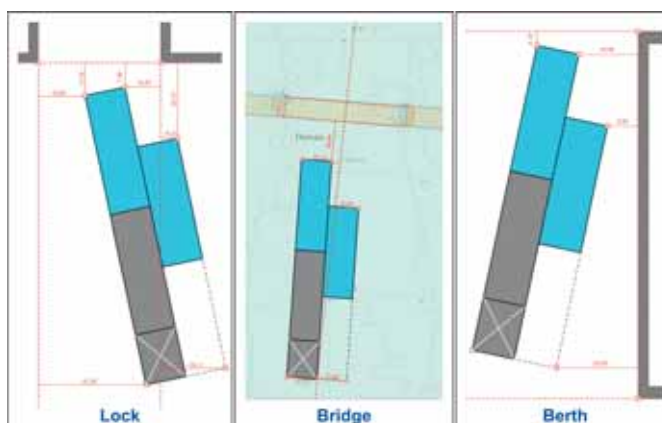
The goal of the application is to provide accurate distance information between vessel hull and close riverside infrastructure in real-time. Based on this concept, the expected GNSS performance requirements have been determined, taking into account the identified user requirements.

The identification of user requirements and based on that the identifications of suitable application scenarios were the first steps carried out within this project. The aim was to identify applications that require high accurate positioning services and provide operational benefit (in terms of an improvement of safety and/or efficiency) to users on inland waterways.

As a result, three application scenarios have been identified that have a special need for highly accurate positioning information from satellites and aim at improving the safety and efficiency on inland waterways. The information shall support the ship crew in assessing the actual navigation situation correctly and hence

reducing the risk of collisions with infrastructure. In addition, these applications shall increase efficiency as the provided information assists the vessel master to make decisions more quickly and at a higher level of quality.

The information has to be provided to the ship crew in real-time in a suitable (graphical) way in order to maximise the benefit of such a system. An additional feature is the innovative approach to a semi-automated accurate modelling of the vessel/convoy shape. The system shall be integrated into existing inland navigation technologies such as Inland AIS and Inland ECDIS.



NAWWAT Application Scenarios

OEGNOS

Austrian EGNOS Data Server – Business Plan

The driving force for a research project aiming at developing an Austrian EGNOS data server is the requirement for continuous GPS correction data stream with high integrity and continuous availability that facilitates national coverage. The topography of Austria obstructs the direct line of sight signals of the European Geostationary Navigation Overlay Service (EGNOS), therefore alternative transmission methods are considered. Furthermore, GPS/EGNOS signals do not provide the position accuracy required by various applications.

Consequently the Austrian EGNOS data server (OEGNOS) shall provide an EGNOS data stream using authenticated terrestrial communication means and integrate additional local and regional meteorological information (ionospheric and tropospheric information) to provide higher position accuracy and continuous service availability. Specialised hardware or software shall be avoided, instead, standardized protocols shall be used in order to favour market penetration.

Potential applications are agrarian area determination, precision farming, inland waterway navigation or driver assistance systems (e.g. lane keeping). In case that GPS/EGNOS becomes an agreed or even required method for area determination on European level the OEGNOS system provides services within Austria, where EGNOS signals are not available any more.

Before the technical feasibility was shown, a business plan had been elaborated to prove the commercial viability of the OEGNOS idea. Therefore, the OEGNOS services were listed, and a patent research was accomplished. The market analysis of primary and secondary markets shows the addressable markets within Austria, Germany, or Switzerland. The market development was critically elaborated. In the frame of a profit and loss analysis development, marketing, operation, and maintenance costs were opposed to the revenues and the break-even point was determined. Finally the risks of the development, of market introduction and of market development have been critically questioned.

The conclusion of the business plan of OEGNOS indicated that the service idea is viable, if the technical feasibility can be shown. This was the motivation for the ASAP 6 project OEGNOS 2.

The OEGNOS idea was awarded at the European Satellite Navigation Competition 2008 in the category of GSA special topic prize.

Infobox

Project duration:

1 May 2008 – 30 November 2008

Coordinator:

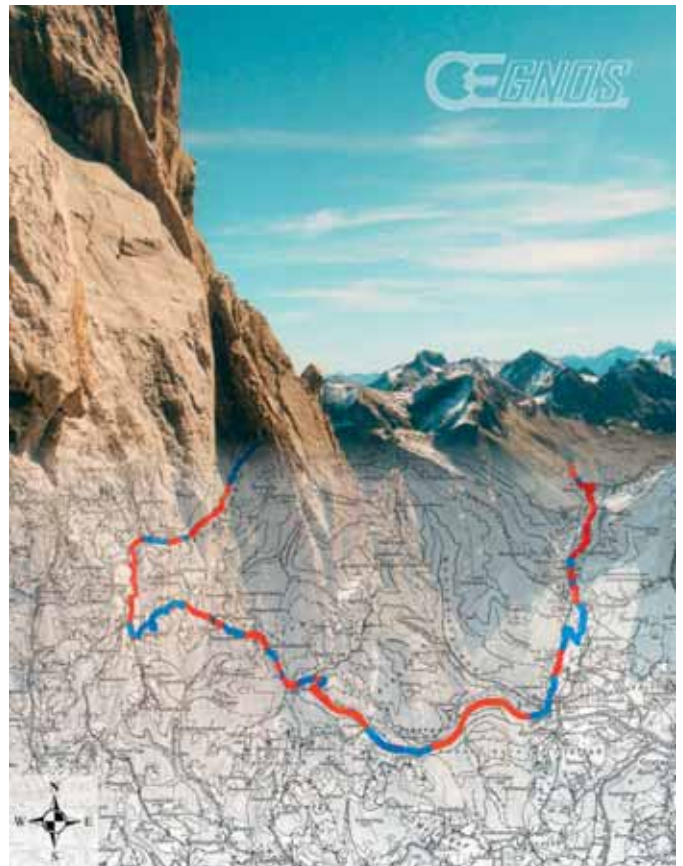
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Due to topography EGNOS signal is not available in some areas.

Map © BEV; photo © TeleConsult Austria

OEGNOS 2

Austrian EGNOS Data Server



Local weather station used for atmospheric correction

The accuracy of satellite based position determination and navigation can be improved significantly using miscellaneous correction processes, like terrestrial differential services (DGNSS) or Satellite Based Augmentation Systems (SBAS). The European contribution to SBAS, the European Geostationary Navigation Overlay Service (EGNOS), became operational in October 2009, when the European Commission launched EGNOS open service that offers free access service to citizens and business. The potential of the EGNOS service, however, can not be fully exploited within the Alps, since the satellite signal is shaded in many cases by topography. Furthermore, EGNOS accounts for ionospheric effects on a European scale, but cannot reflect local ionospheric conditions and does not take tropospheric conditions into account.

The Austrian EGNOS data server (OEGNOS) provides an EGNOS correction data service especially tailored to these requirements. To improve deficiencies due to the local atmospheric conditions, local meteorological parameters,

derived from real measurements, are integrated into the EGNOS corrections. Therefore, the EGNOS correction data-stream is decoded, supplemented by the computed local ionospheric and tropospheric corrections, encoded into a RTCM format and provided to users via an authenticated terrestrial communication connection. Consequently, the service availability increases due to the application of terrestrial communication while at the same time off-the-shelf receivers can be used without the need for special software updates. Local tropospheric corrections are based on the measurements of the local weather station at the University Centre of Rottenmann. Alternatively data of a national meteorological data centre could be used.

Due to the improved absolute accuracy of the single point positioning new application areas arise (e.g., agrarian area determination, special inland waterway navigation applications), which cannot be covered by conventional GPS/EGNOS positioning in Austria. Furthermore, the OEGNOS service will provide a service level (e.g., integrity), which is generally not provided by DGNSS.

The first version of this service for test and demonstration purposes covers a local area in the surroundings of Rottenmann (Styria). Rottenmann was chosen because of an existing GNSS reference station, which is used for testing purposes, and a polymorphic area (valley, mountain, rural, urban).



GPS reference station at the University Centre of Rottenmann

Infobox

Project duration:

1 April 2009 – 15 September 2010

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RA-PPP

Innovative Algorithms for Rapid Precise Point Positioning

Is there a chance to achieve dm accuracy in positioning, just by means of an isolated single-frequency GNSS receiver? Which further external data has this isolated receiver to be provided with and within what time frame does the position determination converge to the requested accuracy? These are the crucial questions of Precise Point Positioning (PPP). In the project RA-PPP we show that there are several limiting factors to existing PPP algorithms and services, which rely on highly precise orbit and clock parameters.

Using these external data sources, inaccuracies in the orbit and clock information as well as atmospheric uncertainties can be circumvented. Furthermore, with a dual frequency receiver – eliminating ionospheric effects – centimeter to decimeter accuracy can be achieved. Compared to DGPS and RTK systems, PPP reduces the user's costs – neither a base station nor simultaneous observations are necessary – and local limitations, thanks to at least regionally or even globally valid corrections.

Based on a preliminary analysis of existing PPP services, algorithms and products the scientific members of the RA-PPP consortium (Graz University of Technology and Vienna University of Technology) develop improved and innovative algorithms for rapid PPP.

Particular attention is paid to the attribute "rapid", since nowadays PPP systems can provide accuracies up to centimeter level by long observation periods. Even decimeter accuracy is achievable only after almost half an hour, which makes PPP unusable for a wide range of applications.

Based on their contribution to a PPP error budget and the current deficiencies in data modeling, the following approaches are pursued to achieve improved accuracies and faster convergence of the PPP solution:

- the derivation of improved atmospheric models for single frequency users
- the use of "regional clocks"
- the use of new ionospheric free linear combinations with reduced phase noise
- a simulation to solve for ambiguities by introducing apriori receiver and satellite dependent bias tables

The newly developed algorithms are implemented into a PPP user module for static and kinematic observations by TeleConsult Austria GmbH. This module is further used to evaluate the performance of the algorithms in terms of convergence time, accuracy and availability, whereby all necessary data is provided by Wienstrom GmbH.

Infobox

Project duration:

1 May 2009 – 31 August 2010

Coordinator:

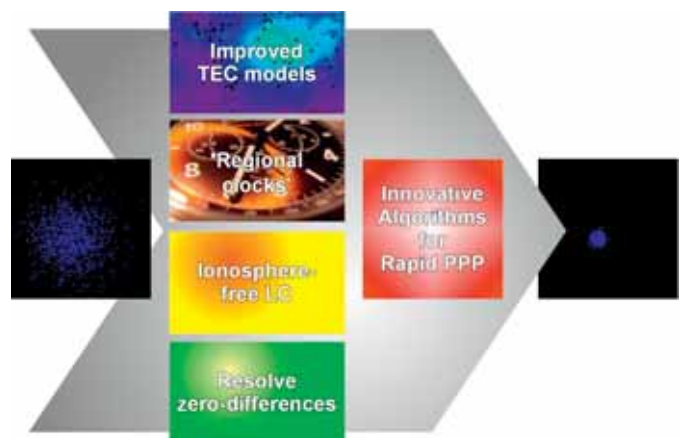
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Project objectives

SoftGNSS 2

SoftGNSS 2 – A Dual Frequency Software-based GNSS Receiver

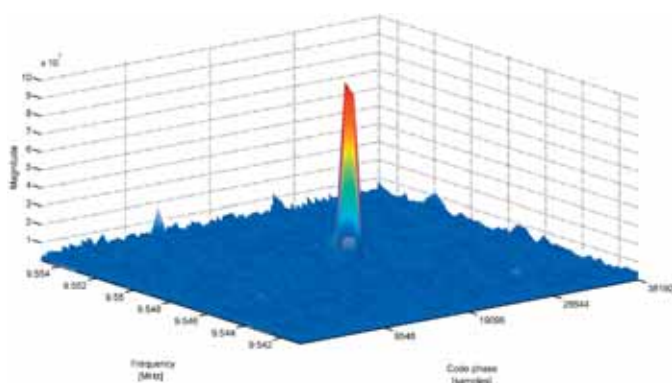
Within the last decade, a significant trend towards the development of software-based Global Navigation Satellite System (GNSS) receivers has evolved, because since that time, the necessary computation power has been available. Software-based GNSS receivers are highly flexible concerning the adaptation to several applications. They serve as a development platform investigating new algorithms and techniques and have the advantage of only few necessary hardware parts. Thus, a small overall size is achievable and hence makes it easy to implement those receivers into mobile devices, e.g. cell phones. Due to the flexible architecture they can be easily integrated into those devices with other sensors for the purpose of position determination and are therefore excellently applicable to a wide range of applications.

The main focus of current developments is the single frequency approach, aiming at mass market applications. However, the resulting position accuracy is not sufficient for many applications. Nowadays the automotive domain or security relevant applications for example strongly demand a higher position accuracy ($\leq 1\text{m}$).

Beside the errors introduced by the satellites (orbit, clock, etc.), the troposphere and the receiver clock, the ionosphere is one of the biggest error sources. Adding a second measurement, using a different carrier frequency, the error due to the ionosphere can be eliminated. Furthermore, integrity can be increased, which is inevitable for a wide range of applications as well.

To fulfil the mentioned accuracy requirements within the project SoftGNSS 2, a software-based dual frequency GNSS receiver has been developed.

The main goal of this software-based receiver development is to implement the signal processing as far as possible in software, and thus the required hardware can be reduced to a minimum. This decreases the costs for future mass market products and



SoftGNSS acquisition result using a digital IF input signal

Infobox

Project duration:

1 June 2009 – 31 October 2010

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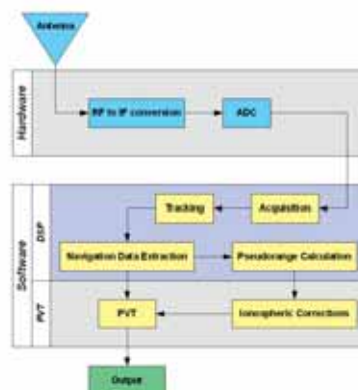
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increases the flexibility of the system. In a first step the receiver is only capable of processing GPS code measurements but makes use of both currently available civilian signals. The second civilian signal L2C, available on the second carrier frequency L2, is under construction at the moment, but eight satellites already transmit this signal. For the future, the adaptation to other GNSS, especially Galileo, has been planned and thus availability and position accuracy can be further increased.



SoftGNSS system architecture

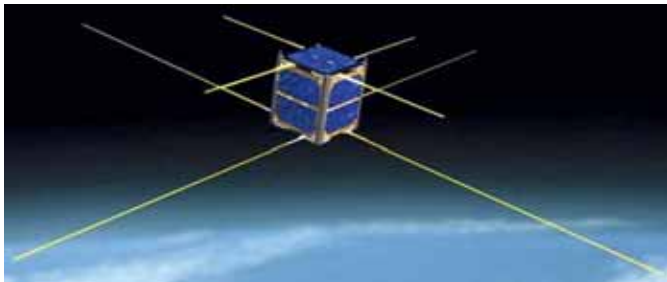
Outreach

Pre-DOMIQASOL

xgravler

Pre-DOMIQASOL

Feasibility Study for a Distributed Orbital Measurement Instrument for Quality Assurance of Scientific Operation Space Links



Artwork of the projected measurement satellite

Satellite link quality analysis is a continuously emerging field for the optimization of the data link return from (academic) satellite missions, in particular within global ground station networks. It can provide detailed information about a satellite's and ground station's status and can be correlated with environmental influences in order to derive a link quality prediction model. Furthermore, it is of significance for satellite orbit determination, noise level determination, and further topics.

Recent scientific investigations proved that link quality can be used for the optimization of satellite missions, but they have also discovered that the current, passive methods for measuring link quality using ground station hardware are exhausted. Although the achievable precision leads to reliable prediction models, their granularity and consequently the precision of the models is limited.

In order to be able to open up new research domains and to optimize the current results, a more precise measurement process and instrument are required. The proposed approach is the development or usage of a custom radio on a CubeSat platform for performing measurements in both up- and downlink direction.

The performed feasibility study validates the possibility of performing active, high-precise measurements using a satellite based on the CubeSat platform standard being equipped with a custom UHF radio module. A possible set-up has been presented for performing active measurements with the application of global ground station networks. Furthermore, a detailed requirement and risk analysis has been performed. Several scientific and business applications for the proposed measurement instrument have been identified and described in detail.

Infobox

Project duration:

1 April 2009 – 16 October 2009

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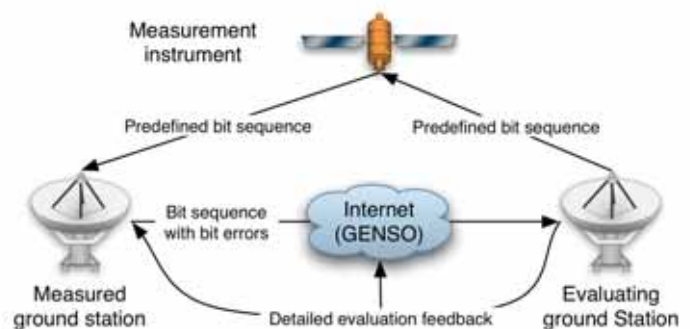
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The presented study is a precursor for a follow-up ASAP project aiming at the construction, test, and deployment of the designed instrument in the first phase and the collection and scientific evaluation of a large number of quality measurement in the second phase. The projected measurement instrument can be carried whether as primary or secondary payload on a CubeSat satellite. Possible European academic and industry partners have been identified for both scenarios. Together with professional satellite industry, detailed cost and time schedules have been developed, aiming at the orbit deployment of the instrument in 2011–2012.



The proposed link quality measurement set-up

xgravler

Experimental Gravity Research with LEGO-based Robotics Onboard a Stratospheric Research Balloon

The REEL-E payload, the final implementation of the xgravler project, measures the g-forces under changing conditions in high altitude environments. For this, the payload was put into a stratospheric research balloon during a mission named H.A.L.E., organized by the University of Reno, Nevada, and sponsored by the NASA Space Grant, Energizer, LEGO and National Instruments. The balloon was launched on 29 July 2008 from the Nevada desert, close to Reno, USA, and reached an altitude of just over 99,500 ft (~30km).

This project was realized using a LEGO Mindstorms NXT processor in combination with a three-axis accelerometer (very similar to the one used at a Nintendo Wii Remote), and some additional electronic hardware to execute experiments on micro-gravity (μg) generation in high-altitudes. The main purpose of the mission was to check the feasibility of our idea.

The implementation used two payloads, dubbed REEL and E, connected by a tether and a Bluetooth communication-link. The REEL payload drops E, during which it would experience a few moments of free-fall, and reels it back in. During the free fall the acceleration is measured and then sent back via wireless link. This experiment was repeated 24 times over the course of the balloon flight.

μg is useful for a variety of scientific research areas ranging from crystal formation, biotechnology, medical/drugs research, fluid physics research to the emerging field of nanotechnology. A follow-up mission named reel.SMRT was selected and funded by the European Space Agency (ESA) and the German Aerospace Center (DLR). In 2009 payloads flew on one of the BEXUS balloons.



Picture taken at the highest altitude during the ascent (at around 30km) just before the burst of the balloon. (Courtesy of the HALE team)

Infobox

Project duration:

1 May 2008 – 31 October 2008 (ASAP start: 07 July)

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The payload attached to the balloon and ready for lift-off.

Space Science

BRITE-Austria

CDSM-FS

DFG-MFA

DOSIS

EMA

ENZYME-CHIP

HP3-PP

MATSIM Phase-B

MDS

MERMAG 3

Metallic Melts 2

MicroColumbus

ORTHOCAP

PICAM

SOLDYN

TMIS_morph

BRITE-AUSTRIA

BRITE-Austria Operations Phase IIb & III

The BRITE (BRight Target Explorer) mission aims at the long-term investigation of the brightness variation of massive, luminous stars by differential photometry.

Funded by the Austrian Space Applications Programme the first Austrian satellite BRITE-Austria/TUGSAT-1 has been designed and built. It is currently undergoing unit-level and qualification tests at Graz University of Technology. The nanosatellite utilises recent improvements in three-axis stability control by pioneering Canadian space technology to the level of 1 arc-minute. This is achieved by miniature momentum wheels and a combination of star tracker, sun sensors and a magnetometer as attitude sensors, opening up a totally new domain of miniature, low-cost spacecraft for astronomy and other high-precision space missions. The nanosatellite carries a small astronomical camera with a large field-of view as payload.

The spacecraft will be launched on a Polar Services Launch Vehicle (PSLV) of ISRO/ANTRIX from Southern India scheduled for the begin of Q3 in 2011. The parameters of an 800 km sun-synchronous orbit with 0600 LTAN are ideal for the scientific goal.

Phase IIb (ASAP 5) of the project was mainly concerned with the development of the first part of the science and ground segment control software. In addition, a mission analysis was performed, including science goals and targets, payload and spacecraft design, mission design and launcher, and ground segment and operations.

Phase III (ASAP 6) deals with the launch integration and the command software development. The activities concerning the launch include the acceptance testing, the transport of the satellite to the launch site, the prelaunch testing and final integration on the rocket. Furthermore, software modules for converting the observation parameters into satellite commands (including attitude and camera settings) are developed.

The project involves master and PhD students to a significant extent. This enables students to get hands-on experience in design, manufacturing, testing and operations of a spacecraft as well as management of space projects. The project management and key developments are carried out by faculty staff of the universities to ensure timeliness and sustainability after the project for future missions.

Infobox

Project duration:

Phase IIb:

1 January 2009 – 30 September 2009 (ASAP 5)

Phase III:

1 September 2009 – 31 December 2010 (ASAP 6)

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Antenna tower at the groundstation in Graz.

CDSM-FS

Feasibility Study of a Coupled Dark State Magnetometer (CDSM)

An absolute scalar magnetometer offers superior stability and offset-free measurements of the magnetic field magnitude. In space, it is used for improving the absolute accuracy of vector magnetometers, which also measure the direction of the magnetic field. In several cases, full science return can only be achieved by a combination of vector and scalar magnetometers.

Existing scalar magnetometers are based on complex instrument designs, which have significant mass and power consumption. A miniaturized scalar magnetometer is therefore a key technology for a number of future space missions (e.g. ESA's Europa Jupiter System Mission to Jupiter's moon Ganymede).

In the frame of this project a feasibility study of a new type of scalar magnetometer called Coupled Dark State Magnetometer (CDSM) was carried out. It included the investigation of its technical readiness and scientific merit for space applications, the concept for a TRL 5 (component and/or breadboard validation in relevant environment) compliant design, a detailed investigation of key components as well as the identification of possible challenges for a reliable operation in space.

The CDSM is a kind of optically pumped magnetometer. This means that the energy from a light source (e.g. laser diode) is used for exciting electrons in an atom in order to gain information about the magnitude of the surrounding magnetic field. In case of the CDSM the optical source is a specially modulated laser light, which excites Rubidium atoms stored in a glass cell. The measurement of the magnetic field is based on the Zeeman Effect in free atoms. Here, the energy shift of the atomic levels is described by the so called Breit-Rabi formula, which only contains fundamental natural constants (such as Landé factors, Bohr's magneton and Planck's constant). Therefore, the determination of magnetic fields is reduced to a frequency measurement, which can be done with highest accuracy.

During the feasibility study improvements have been made to a TRL 3 (characteristic proof of concept) compliant test set-up for a better resource estimation of the most relevant instrument parts. The current best estimates for mass and power are 700 g and 1.0 W, respectively. All technology and every component are available so that there is nothing that could prevent a further TRL uplift of the CDSM to level 5 and higher.

Infobox

Project duration:

1 June 2009 – 31 March 2010

Coordinator:

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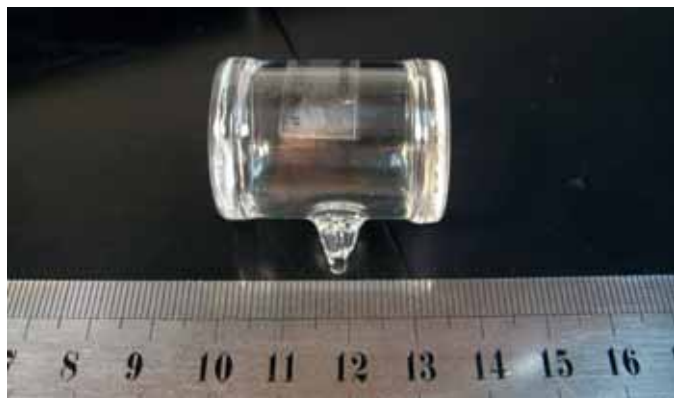
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Partner:

Graz University of Technology

Institute of Experimental Physics

Dr. Roland Lammegger



Rubidium-filled glass cell



Current CDSM sensor unit (TRL 3 standard)

DFG-MFA

Design, Manufacturing and Qualification of the Magnetometer Front-end ASIC for the Digital FluxGate Magnetometer Onboard of the NASA Mission MMS



Engineering model of DFG electronics with space qualified Magnetometer Front-end ASIC in the middle (golden lid).

Scientific instruments for space applications are required to reduce resource requirements, such as volume, mass and power, while at the same time achievement of at least the same performance as conventional instruments is essential. So it is important that especially the instrument front-ends and read-out units undergo miniaturization.

That is why a prototype of an instrument front-end ASIC (Application Specific Integrated Circuit) for magnetic field sensors based on the fluxgate principle has been developed under the lead of the Space Research Institute (IWF) of the Austrian Academy of Sciences financially supported by the European Space Agency (ESA). It is called Magnetometer Front-end ASIC (MFA). With this mixed-signal (analog and digital) MFA in a 100-pin wide space qualified package, it is possible to reduce the required power for the read-out electronics by a factor of 10 and more as well as the area needed on a printed circuit board by a factor of 3-4 compared to magnetic field instruments, e.g., aboard Venus Express (ESA) and Themis (NASA).

Due to the successful prototyping, IWF was invited to participate in the development of the dual fluxgate magnetometer for NASA's Magnetospheric MultiScale (MMS) mission by supplying MFA based electronics for the Digital FluxGate (DFG) magnetometer.

The NASA mission Magnetospheric MultiScale (MMS) will explore the dynamics of the Earth's magnetosphere and its underlying energy transfer processes. Four identically equipped spacecraft are to carry out three-dimensional measurements in the Earth's magnetosphere. The launch of the four spacecraft is scheduled for August 2014.

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Project duration:

1 January 2008 – 31 July 2010

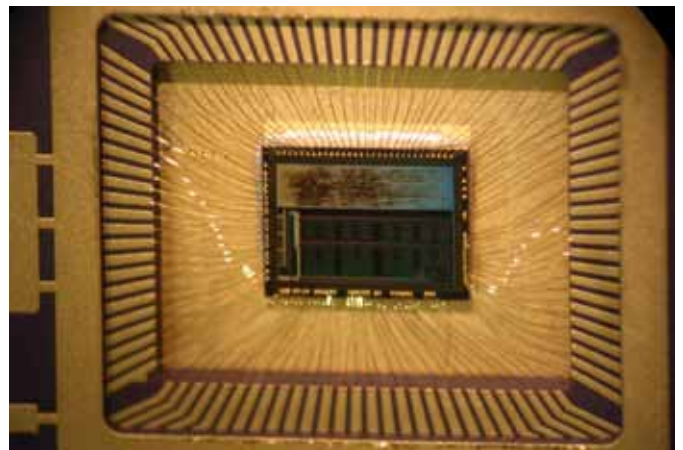
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Packaging and bonding of the Magnetometer Front-end ASIC.

The manufacturing and space qualification of the MFA as well as the development of an Interface Verification Model and an Engineering Model of the DFG electronics were financially supported by an ASAP 5 project from January 2008 to December 2009. The last milestone, completion of the MFA qualification, was achieved in early March 2010.





DOSIS badge installed in the Human Research Facility rack

Although astronaut exposure to cosmic radiation may be reduced by careful mission design and constructive measures, it still seems to be the most essential constraint for long-term human missions of exploration. The radiation environment in space is characterized by a high degree of complexity and dynamics. When the incident radiation penetrates the spacecraft structure, it undergoes a number of nuclear interactions, by which a complex secondary radiation field of charged and uncharged particles arises. The constituents obviously produce distinct biological damage, which – compared to radiation on ground – leads to large uncertainties in the projection of cancer and other health risks, and obscures evaluation of the effectiveness of possible countermeasures. Accurate risk evaluation depends on the degree of knowledge of the physical characteristics of the radiation field inside the space vehicle.

Realized in the frame of the ELIPS programme of the European Space Agency, the DOSIS experiment is a multi-lateral research effort to determine absorbed dose, particle flux density and energy spectra at eleven differently shielded locations inside the European Columbus module of the International Space Station. Fully autonomous radiation sensors are also implemented in the EXPOSE exobiology experiment on the extravehicular European Technology Exposure Facility (EuTEF). Application of a broad variety of instrumentation, e.g., alternating layers of thermoluminescence (TL) and plastic nuclear track detectors, allows for covering the entire charge and energy spectrum and cross-calibrating the measurements. The Institute of Atomic and Subatomic Physics of the Vienna University of Technology contributes one fifth of the employed TL dosimeters. The energy absorbed from ionizing radiation is stored at controlled lattice defects or impurities in alkali halide crystals and re-emitted as luminescence light upon heating in the laboratory. The light intensity is a measure of absorbed dose and radiation quality. The gained know-how will support the improvement of particle transport algorithms and constitute essential information to the refinement of radiation protection standards for human spaceflight. The developed prototype area dosimeter could later be implemented into Columbus operational dosimetry and would hence indirectly lead to an improvement of the economic impact.

Infobox

Project Duration:

1 July 2008 – 30 June 2011

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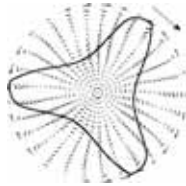


European Columbus module on orbit



Axial view of a particle accumulation structure with period $m=3$ in an experiment of Schwabe et al. (2007) (mirror image).

Axial view of a particle accumulation structure with period $m=3$ in a numerical computation (full line).

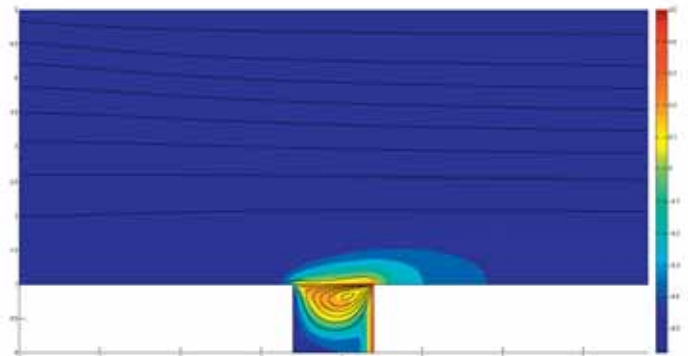
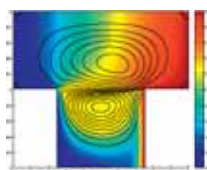


The handling and manipulation of liquids is a key requirement for manned and unmanned space flights. Some examples are the liquid propellant of rocket engines and the drinking water for astronauts.

If a liquid gets in contact with a gas, capillary forces act on the interface. An important effect driving a significant liquid motion is the Marangoni effect. It arises when the liquid-gas interface is locally heated or cooled. An example is the migration of oil to the colder rim of a heated pan. As the effect is independent of gravity, it is a prime driving force for fluid motion under weightlessness. The Marangoni effect is also important in crystal-growth technology for semiconductor manufacturing, since the flow induced in molten silicon has a crucial effect on the quality of the single crystal grown.

A paradigm for Marangoni flows is the liquid bridge problem in which a liquid droplet is confined between two solid cylindrical rods that are kept at different temperatures. In the EMA project scientists aim at controlling the Marangoni flow in the liquid phase by eliminating the effect of buoyant convection which eclipses the Marangoni flow on the ground. An international team consisting of scientists from Austria, Belgium, Spain and Japan is working together in the JEREMI project to manipulate and shape the Marangoni flow in the liquid by exposing the liquid bridge to an external gas stream whose strength, temperature, and chemical composition are well controlled.

Apart from gathering important information required to keep the flow laminar as long as possible, the scientists also want to unravel the reasons for a unique effect which leads to a demixing of small solid particles suspended in the liquid: after a short transient time all particles in the liquid bridge align along a wavy ribbon, which rotates about the cylindrical axis of the liquid zone.



Steady streamlines and temperature field (colour) in a liquid bridge and in the exterior gas phase for a closed gas compartment (Fig. left) and for an open gas phase with imposed axial through flow (Fig. right). The cylindrical axis of symmetry is at the bottom of the figures.

Infobox

Project Duration:

1 July 2009 – 31 December 2010 (an extension is planned)

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(Coordinator of the Austrian part of the project)

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The research within the JEREMI project will be carried out as a joint ESA/JAXA experiment on the Japanese Module KIBO utilizing the Fluid Physics Experiment Facility (FPEF) and the Image Processing Unit (IPU) onboard the International Space Station (ISS). The ESA activity is performed within the ELIPS programme. The Austrian part (EMA) of the JEREMI project is the numerical simulation of the phenomena to predict suitable parameters for the space experiment and to analyze the phenomena theoretically. A detailed understanding of the fluid mechanics of this flow will also serve to improve industrial processes on the ground.

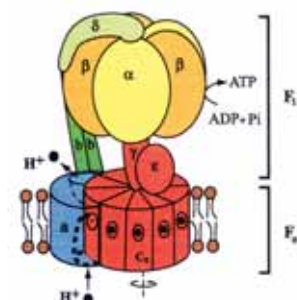
ENZYME-CHIP

Preparation for Life Marker Chip Experiments with the Universal Enzyme ATP-Synthase



ExoMars rover with drilling device (photo credit ESA)

The revised ExoMars mission will be carried out as a joint project by NASA and ESA. Newly released plans call for an orbiter, to be launched in 2016, and for a two-rover mission – one rover provided by NASA and the other by ESA – to be launched in 2018. ESA's ExoMars rover will carry analytical instruments dedicated to exobiology and geochemistry research; it will collect samples from outcrops and from the subsurface with a drill down to a depth of two meters (Fig. left, top).



Model of the universal enzyme F₁F₀ ATP synthase

Samples will be analysed for biomolecules in order to look for extant or extinct life. The Life Marker Chip (LMC) instrument proposes to use receptors such as labeled antibodies for the detection of biomarkers. Universal enzymes, which are present in highly conserved forms in all organisms, are the ATP synthases or ATPases (Fig. left, bottom); therefore they should be ideally suitable candidates for the LMC. Since salt has been detected on

Mars, it appeared feasible to carry out studies with enzymes from extremely halophilic archaea. Novel procedures for the use of antibodies against subunits of the ATPase enzymes were developed in this project. Antisera against the two major subunits of the ATPase from the halophilic archaeon *Halorubrum saccharovororum* were examined concerning their applicability in highly sensitive immuno assays. In addition, an antibody from rabbits against a peptide from the related V-ATPase from humans was purchased from a company. Immunological cross reactions of the antisera against the ATPase subunits from *Hrr. saccharovororum* and the human V-ATPase with ATPase-enriched membranes and whole cells, respectively, of a related archaeon (*Halobacterium salinarum*) and two bacteria (*Escherichia coli*; *Bacillus megaterium*) as well as bacterial endospores (*Geobacillus stearothermophilus*) were obtained (Fig. right).

These data confirmed the deep evolutionary relatedness of the enzyme ATPase/ATP synthase to different organisms. Therefore, the enzyme can be considered a useful candidate for extraterrestrial life detection experiments.

Infobox

Project duration:

1 August 2009 – 31 January 2011

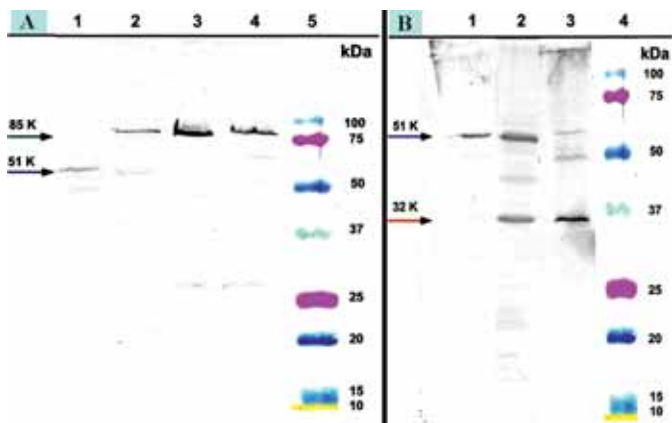
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Immuno reactions, indicated by dark bands, between antibodies against the ATPase enzymes from humans, bacteria, spores and halobacteria. Lanes A5 and B4 contain coloured markers.

HP3-PP

Development of the HP3 Permittivity Probe Onboard the ESA ExoMars Mission

The investigation of the surface of other celestial objects, mostly of the planet Mars, currently is the major driver of robotic exploration. For this purpose instruments must be developed, which can autonomously perform field measurements and which fit in the tight resource envelope of a space mission.

Together with the DLR Institute of Planetary Research the HP3 (Heat flow and Physical Properties Probe) instrument was developed to investigate the thermal, mechanical and electrical properties of soil. The whole instrument is embedded in a mole penetrator, i.e. a mechanical instrument carrier resembling a nail with integrated hammering mechanism, which will deliver the sensors up to a depth of five meters into the Martian soil. This suite of geophysical sensors was initially designed to be a part of the Geophysical Package (GEP) of the ExoMars mission. After the cancelation of the GEP and the postponement of the ExoMars mission it was decided to continue with the instrument development to a high TRL level as a laboratory model and to propose it to upcoming missions to Mars and the Moon.

The Space Research Institute (IWF) is in charge of the permittivity probe (PP) within the HP3 instrument. The probe shall determine the electrical permittivity and conductivity of the soil adjacent to the sensor. The basis of the sensor implementation is derived from classical geoelectric methods. However, driven by the need to accommodate the whole sensor to a down-the-hole instrument, a new front-end electronics has to be developed. Constrained by the geometric envelope of the HP3 payload compartment, a small sized two channel vector analyser was designed spanning the frequency range of 4 – 20 000 Hz in a step size of 1 Hz. The whole design is already sized for the larger flight qualified electrical components and once fully tested and calibrated should be ready to be used on a flight design campaign on short notice.

The knowledge of the permittivity of a soil can be used not only to characterise the adjacent material in terms of electrical properties, but can also help to detect inhomogenities like layers or inclusions and of course is quite sensitive to even small amounts of water within the soil. As additional information, it can help to provide "ground truth" for ground penetrating radars in orbit such as the Marsis radar on the MarsExpress mission.

Infobox

Project duration:

1 January 2009 – 31 December 2010

Coordinator:

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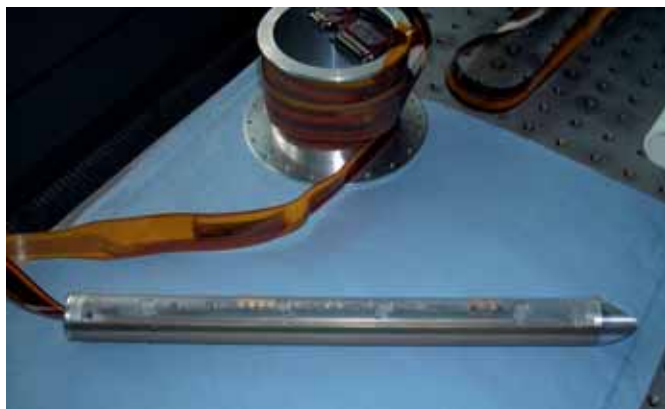
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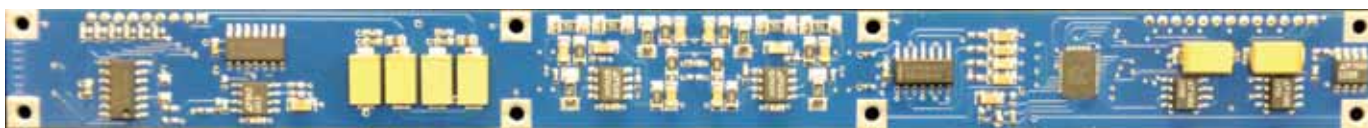
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The PP instrument during an integration test for the HP3 ESA preliminary design review (PDR). The HP3 instrument was rated by ESA as TRL 5 during that review.



Accommodation test of the HP3 instrument. All four front-end electronics boards were mechanically integrated into a to scale mock-up of the HP3 payload compartment.



Front-end electronics of the HP3 permittivity probe. On a PCB size of 20 x 200 mm a two channel vector analyser and waveform generator is implemented.

MATSIM Phase-B

Verification of the Numerical MATROSHKA Model and Monte Carlo Simulations in the ISS Radiation Environment



Figure 1: From left to right: The MATROSHKA phantom, a computer tomography of MATROSHKA, the phantom's geometry, simulation results of energy imparted in the phantom due to isotropic photons (front and side view).



Figure 2: Experimental TLD results of the depth dose distribution due to frontal photon exposure of the MATROSHKA phantom (left and right top) and comparison with simulation results (right bottom).

The aim of MATSIM Phase-B is the validation of the numerical simulation model of MATROSHKA for photon and neutron reference radiation fields, which are available in Austria. The project MATSIM is a co-investigation of the ESA ELIPS-project MATROSHKA, a world wide collaboration that comprises 21 research institutes. MATROSHKA is a facility designed to determine the radiation exposure of an astronaut during an intra- and extravehicular activity at the International Space Station (ISS).

The reference irradiations of the MATROSHKA phantom were carried out at the radiation standard laboratory in Seibersdorf and the nuclear research reactor at the Institute of Atomic and Subatomic Physics of the Vienna University of Technology. The measurements inside the phantom were accomplished with thermoluminescence dosimeters (TLDs) and an ionisation chamber for frontal and multidirectional incidence. During the previous project phase A a numerical model of the MATROSHKA phantom called MATSIM1.0 was developed using the Monte Carlo code FLUKA (see Figure 1). FLUKA simulates the interaction and propagation of different particles, such as photons, electrons, hadrons, neutrons and heavy ions, in a wide energy range. In addition to the established torso model of MATROSHKA, a high resolution voxel-based numerical model of the MATROSHKA head was developed in MATSIM-B. Both models are used to simulate the response of dosimeters within the MATROSHKA phantom (see Figure 2). The congruence between the measured and simulated data is used to verify the numerical model. While in MATSIM-B the validation concerning neutrons and photons is carried out, further reference measurements have already been planned for proton and heavy ion radiation fields at a next project phase. Protons are the most important contribution to the space radiation environment. Heavy ions show the largest radiobiological effectiveness to tissue.

The MATSIM project will provide a validated and high resolution numerical voxel model of MATROSHKA. The model MATSIM1.0 will be used for space dosimetry to calculate the depth dose distribution within the phantom due to the complex radiation fields present at ISS, on Mars or for further space missions. The gained expertise is also important for cancer therapy and medical applications in proton and heavy ion dosimetry, which will be carried out at MedAustron in Austria.

Infobox

Project duration:

1 April 2009 – 30 September 2010

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MDS

Multifunctional Dynamometer for Application in Space

In the project MDS – Multifunctional Dynamometer for Application in Space – the Institute for Engineering Design and Logistics Engineering (IKL) of the Vienna University of Technology, the Centre for Sports Sciences and University Sports (ZSU) of the University of Vienna and the Institute of Biomedical Problems (IBMP) of the Russian Academy of Sciences develop a training and diagnostic device for an application in space.

This project was motivated by the excellent results of the cooperation during the “Motomir” project, which started in 1991 and also based on the knowledge collected in these experiments. The new concept is orientated on a variety of different resistance exercises in combination with the rowing exercise as a training option for the cardiovascular system. The training-force is produced by an electric motor and is linked to a training-bar with two ropes. This kind of concept facilitates to implement various training-exercises, which activate many different and large muscle chains. Thus, a time-saving and intensive training for the whole body can be achieved. In addition to the free movement exercises a linear and rotational guiding system is included to offer the opportunity for exact and repeatable diagnostics conditions to gather exact information about the physical condition of the user. This concept was presented to the Institute of Biomedical Problems of the Russian Academy of Sciences and refined for an application in the isolation project “MARS 500” at IBMP in Moscow and on the ISS. During the period of ASAP 5 (2007–2009), two prototypes of the multifunctional training device were designed and built. One of the prototypes has already been used in a 105-day-test of the isolation project “Mars 500”.

The intended participation of the MDS in the 520-day-isolation of “MARS 500” project offers a unique possibility to test the long-term feasibility gathering valuable information on the topic. Our partners from the IBMP have once more expressed their interest in the use of the MDS on the ISS. Furthermore, an application of the MDS in the field of rehabilitation is planned.



Back extension on MDS

Infobox

Project Duration:

1 November 2007 – 30 June 2009

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Mars 500 crew and a crew member performing squat on MDS

MERMAG 3

BepiColombo/Mercury Magnetometers



Mercury Magnetospheric Orbiter.

The satellite mission BepiColombo to Mercury, the planet closest to the Sun, will have two spacecraft, the Japanese Magnetospheric (MMO) and the European Planetary Orbiter (MPO), synchronously orbit around the innermost planet of our solar system. The BepiColombo composite spacecraft is setting off in August 2014 and will arrive at Mercury in 2020.

A European-Japanese consortium of scientific institutions has been formed to carry out the magnetic field investigations aboard both spacecraft. The coordinated studies will focus on the planetary magnetic field as well as its dynamic interaction with the young and strong solar wind in this region. The teams contributing to the magnetometer hardware are from ISAS Japan, TU Braunschweig, Imperial College London, and IWF Graz. IWF is the lead institution for the magnetometer aboard the Japanese MMO (MGF), while for the MPO magnetometer (MAG), IWF is responsible for the overall technical management. Apart from the management activities, IWF is in charge of the instrument controller and onboard software development, instrument integration and calibration as well as the procurement of space-qualified integrated circuits. Both instrument designs are based on a digital fluxgate magnetometer, which has been developed for magnetometers aboard the Rosetta/Lander, Venus Express and Themis spacecraft. For the BepiColombo mission it is being modified so that it can cope with the harsh thermal environment around Mercury where sensor temperatures up to 180°C are expected.

The ASAP 5 funding covers the development of the qualification, flight and spare models of the Instrument Controller Unit (ICU), the completion of the ICU software, the procurement of all high-

Infobox

Project duration:

1 February 2009 – 31 December 2014

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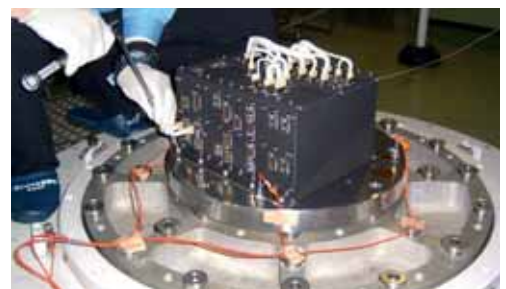
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Imperial College, London

Chris Carr



Vibration test of the MMO common instrument electronics box.

reliability components for the instrument controller as well as instrument testing on instrument and spacecraft level including near Earth commissioning at the end of 2014.

The leading role of IWF in key instruments (MERMAG and PICAM) of the ESA/JAXA BepiColombo cornerstone mission ensures the continued visibility of Austria at the forefront of planetary space research.

Metallic Melts 2

Electrical Resistivity Measurement of High Temperature Metallic Melts – 2



Temper colours



Red heat during manufacturing of CuNi alloys

This project has directly continued the research done in the frame of its preceding project "Electrical Resistivity Measurement of High Temperature Metallic Melts". Again, it is a collaboration of the German DLR and the TU Graz. Unlike its predecessor, it focuses on the measurements of alloys. The pulse heating setup at TU Graz serves as a benchmark for the results obtained from the levitation setup of DLR. The latter is designed to be carried out in microgravity environment. At this stage, parabolic flights with prototypes prepare for a future mission aboard the ISS.

Our pulse heating method is especially suitable to measure the liquid phase. It can be operated without any crucible or levitation device. High heating rates of approx. 10^8 K/s and the short experimental duration (generally 50 μ s) simply prevent a divergence or drop down of the liquid sample. The liquid state is of great interest for the metal-working industry. In comparison to highly alloyed steels, binary alloys are more suitable for a research project like ours. Properties of the alloy can be traced back to the properties of the pure ingredients. Nevertheless,

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Project duration:

1 September 2008 – 30 September 2010

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alloys of industrial relevance were chosen for investigation. For example, the so-called 'resistance alloy' constantan consists of copper and nickel (Cu55Ni45 mass %). This system was investigated at five different compositions. Results were compared to pure copper and pure nickel. The roughly 'constant' resistivity throughout the liquid phase makes this material a candidate for calibration measurements with the levitation setup aboard ISS. There is a good congruence between the results for electrical resistivity in the liquid phase at 1750 K and the results from the levitation setup measured on Earth. Two models, calculated from pure copper and pure nickel, were also taken into consideration. This work is a nice demonstration for the interaction of basic research, applied physics, and theory, driven by the challenge of space exploration.

CuNi samples were cast at the Austrian Foundry Research Institute (ÖGI) in Leoben. The pictures show some impressions of casting and the correlated phenomena.

MicroColumbus

Effects of the Space Environment and Microgravity on Cells of Halophilic Archaeobacteria



Sample holders of the ISS experiments ADAPT (left) and PROTECT (right) following dismantling in a work bench. Crystals of halite on quartz discs attached with red glue are visible in the left tray.

Following the successful installation of the Columbus laboratory on the International Space Station (ISS) in February 2008, the ESA facility EXPOSE-E was used to compare the adaptation and survival strategies of microorganisms from different terrestrial habitats. Several extremophilic microorganisms were tested, including the halophilic archaeon *Halococcus dombrowskii*, which was isolated from a 250-million-year-old Alpine salt deposit in Austria. Samples were returned after 18 months of exposure to the space environment (Fig. above).

The experiments were coordinated by the ADAPT project team. The preparation of samples for the part of the experiment involving *Hcc. dombrowskii* was carried out at the University of Salzburg. The effects of space conditions on the cells were analysed for viability by staining with fluorescent dyes and by determination of surviving cells by means of growth experiments. Most of the returned *Halococcus* cells stained green, which indicated viability, whereas red cells were considered non-viable (Fig. right, top). A novel immuno assay for the detection of thymine dimers, which form under intense UV irradiation, was developed and used for the estimation of DNA damage. Haloarchaeal cells, which were embedded in artificial halite for the exposure experiments, accumulated preferentially within fluid inclusions, as was shown with fluorescent cells (Fig. right, bottom). Thus, the cells experience a liquid environment on the ISS. Therefore, the possibility of unknown effects due to microgravity on the cells was explored in this project. A rotary cell culture system from Synthecon (Houston, TX, USA), which is capable of simulating microgravity on a laboratory scale, was used. Preliminary results indicated an increase in resistance to antibiotics as well as alterations in the overall protein composition of those cultures which had been grown in reduced gravity. Similar responses have been reported to occur in *Salmonella* bacteria, which are pathogens. This stresses the importance of investigating the effects of reduced gravity on microorganisms and any possible impacts on space station crews. While halophilic archaea are non-pathogenic, they are good model systems for testing responses to microgravity.

Infobox

Project duration:

1 March 2009 – 30 June 2010

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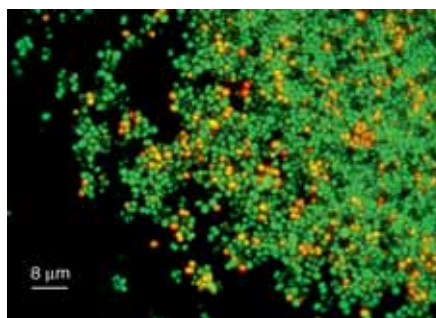
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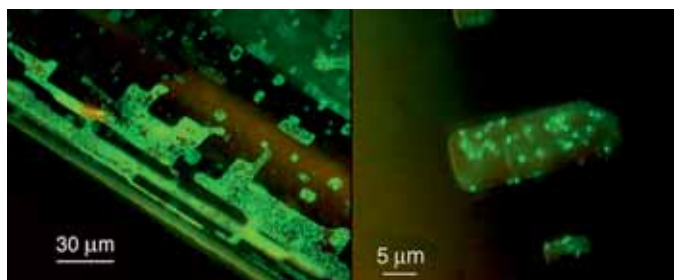
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Cells of *Halococcus dombrowskii* following exposure to 100 % of space radiation on the ISS and subsequent staining with the LIVE/DEAD kit. Green: viable cells, red: non-viable cells.



Pre-stained haloarchaeal cells, which were embedded in artificial halite, accumulate mainly in fluid inclusions. Two different microscopic magnifications are shown.

ORTHOCAP

Use of Plasma Galanin and Adrenomedullin Responses to Quantify Orthostatic Capacity



The Insitute's Automated Multi-Stimulation Test Device for freely adjustable, automated, combined change of pitch (+70° head-up to -70° head-down tilt) and yaw (+30° to -30° sideways slant). An additional lower body pressure system allows for POSUP experiment runs.

Astronauts experience grave problems with blood pressure stability when upright (orthostasis) after space flight. This is because of cardiovascular 'deconditioning' due to the absence of gravitational effects on the blood circulation. The project deals with limits of orthostatic stability in humans and deconditioning effects due to bed rest immobilisation (simulated weightlessness).

The aim of the project is to test the hypothesis that the release of hormones during orthostatic stress follows patterns that indicate particular cardiovascular regulatory states. This is based on recent observations published by the project team: They showed that plasma adrenomedullin concentration rises proportionally with the degree of orthostatic stimulation, whereas plasma galanin does not change until a presyncopal situation is reached, upon which its plasma level increases.

A progressive orthostatic stress until presyncope (POSUP) stimulation paradigm is used (Fig. top). It consists of 4 minutes head-up tilt (HUT), plus additional 4 minutes 15-mmHg lower body negative pressure increments to provoke a presyncopal situation, that is the state preceding imminent loss of consciousness, which is avoided by bringing the test subject back to supine when presyncope is reached. This way, maximum orthostatic competence can be quantified as standing time until reaching presyncope, before and after simulated weightlessness.

In addition to measuring hormone concentration changes (including catecholamines, the renin-aldosterone system, and vasopressin), we monitor heart rate, arterial blood pressure,

Infobox

Project duration:

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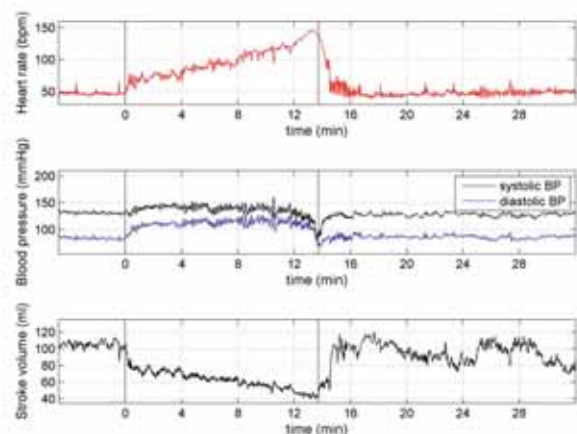
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autonomic nervous indices, baroreflex sensitivity and effectiveness, and markers of blood volume change (plasma mass density, hematocrit) before, during, and after application of POSUP. By these data, orthostatic competence can be explained in depth.

Preliminary results are the following: Among 24 healthy test persons, typical hemodynamic POSUP patterns emerged as expected (Fig. bottom). Parameters of autonomic nervous activity changed according to the degree of cardiovascular challenge. There were big, well reproducible interindividual differences in terms of orthostatic resilience. We found a significant effect of time on plasma vasopressin, renin activity, aldosterone, but not galanin. Other hormones are still to be determined. The bed rest campaign that we will participate in is designed for 2011.

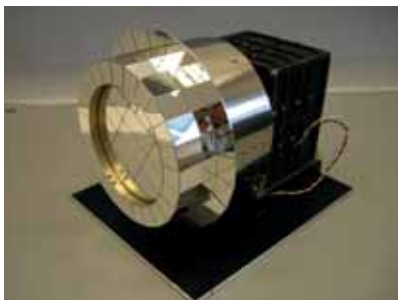


Time course of cardiovascular variables as influenced by the study protocol.

Note the presyncopal decrease in heart rate and blood pressure.

PICAM

Planetary Ion Camera for the BepiColombo Mercury Planetary Orbiter



Structural-thermal model of the instrument PICAM.



The mission BepiColombo to Mercury constitutes a milestone of space exploration, as this planet is very close to the Sun, which makes it a unique place in the solar system. At the same time the hot environment poses great technological challenges. An international consortium lead by the Space Research Institute of the Austrian Academy of Sciences has been selected by the European Space Agency ESA to provide a "Planetary Ion Camera" (PICAM) for the payload of the Mercury Planetary Orbiter to be launched in August 2014. The instrument PICAM combines the features of an ion mass spectrometer with imaging capabilities for charged particles that will allow to study the chain of processes by which neutrals are ejected from the soil, eventually ionised and transported through the environment of Mercury. As a result one will better understand the formation of Mercury's tenuous atmosphere and the plasma within the cavity encompassed by its magnetic field.

The instrument PICAM facilitates high spatial resolution, simultaneous measurements in a hemispheric field of view, a mass range extending up to ~132 atomic mass units (Xenon), and a mass resolution better than 1:50. The instrument consists of a sensor carrying the ion optics, the detector; and an electronics box. A special feature of the processing electronics is the on-board calculation of the ion mass spectra which is based on raw data obtained by random sampling of the incoming ions. Narrow budgets for mass, electrical power, and data rate have to be taken into account. The adverse thermal environment demands a highly reflective outer surface. The PICAM team is a consortium with major contributions from Austria, France, Germany, Belgium, Hungary, Russia, Ireland, and Greece. The Space Research Institute of the Austrian Academy of Sciences leads this investigation and provides the controller and data processing electronics as well as the onboard software: It is also responsible for integration and testing of the instrument amidst the adverse environmental conditions at Mercury and participates in the calibration of the ion sensor, which is crucial for the success of the mission. The present project has been preceded by the instrument design and prototype development and covers the manufacture and testing of the units for qualification and flight as well as the commissioning after launch.

Infobox

Project duration:

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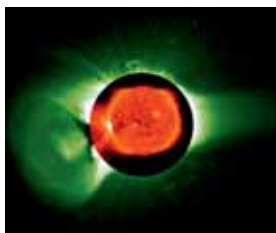
SOLDYN

Dynamics of Solar Flares and Coronal Mass Ejections

Solar flares and coronal mass ejections erupting from the Sun are the most violent phenomena in our solar system. Flares represent an explosive release of energy previously stored in strong magnetic fields associated with sunspots, which leads to localized heating of the solar plasma, acceleration of high-energetic particles and enhanced radiation virtually across the entire electromagnetic spectrum from radio to hard X-rays. Coronal mass ejections (CMEs) are huge structures of magnetized plasma expelled into interplanetary space at velocities of hundreds to a few thousand kilometers per second, occasionally heading towards Earth. Flares and CMEs are closely related phenomena and can cause severe perturbations of our "space weather", i. e. the conditions in our near-Earth space environment that can influence the performance and reliability of space-borne as well as ground-based technological systems.

Many aspects of the basic physics of solar flares and CMEs, how they relate to each other, and how they affect our Earth system are still not fully understood. In the project SOLDYN we use the unprecedented observational capabilities of the recent NASA Solar Terrestrial Relations Observatory (STEREO) and Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESI) missions to investigate the physical processes in solar flares and CMEs. The STEREO mission consists of two spacecraft with identical instrumentation for observations of the faint outermost layer of our Sun, the corona. STEREO-A is moving ahead, STEREO-B behind Earth in its orbit around the Sun, thus facilitating the first three-dimensional view of CMEs. The Extreme Ultraviolet Imager (EUVI) and COR instruments onboard STEREO provide high cadence imaging of the inner solar corona. This is a highly important region for CME dynamics since it is located at the place where the impulsive CME acceleration takes place due to the expelling magnetic forces. The energy release in the associated flares is best studied in hard X-rays, as currently observed with high spatial, spectral and temporal resolution by NASA's RHESI mission.

In SOLDYN we investigate three main topics: (1) the impulsive acceleration phase of CMEs, (2) the CME's relation to the associated flare's energy release, and (3) the CME source region characteristics and how they relate to the CME dynamics. These aspects provide essential ingredients for better understanding and modelling the physics of solar flares and CMEs.



Composit of STEREO EUVI (orange) and COR1 (green) images of a coronal mass ejection erupting from the Sun.

Infobox

Project duration:

1 April 2009 – 30 September 2010

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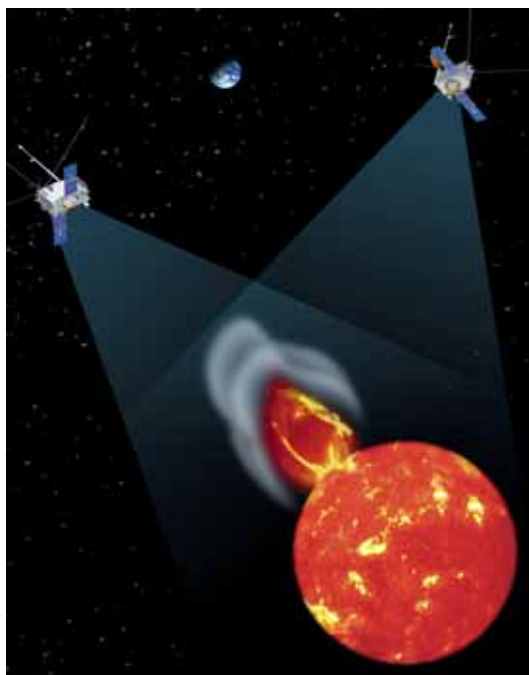
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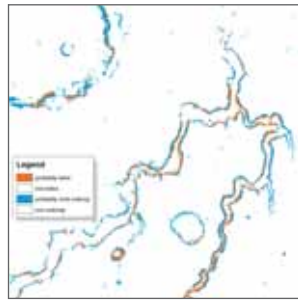
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Artistic representation of NASA's STEREO mission showing the twin STEREO spacecraft observing a coronal mass ejection from different vantage points. Image credit: NASA



Shaded relief of the test area Nanedi Valles (6°24'N, 47°57'W). This picture has been provided by ESA, DLR and the PI Prof. Neukum, FU Berlin.



Result of an unsupervised classification showing the most probable talus pixels in red. The actual valley bottom is between the two undulating ribbon-like zones.

One of the most exciting targets in space research nowadays is the planet Mars. Its environmental conditions, morphology (in case of Mars this science is called areomorphology – derived from the Greek word Ares – instead of its terrestrial counterpart geomorphology) and its evolution history are very fascinating and the research almost daily brings new results and new concepts.

The preparation, launch and operation of the probe Mars Express (MEX), a mission of the European Space Agency, is a real success story, since it has exceeded all expected time frames.

TMIS.morph, a project in the sequence of TMIS (Topographic Mars Information System) projects, was the Austrian contribution to the international collaboration of "HRSC (High Resolution Stereo Camera) on MEX", lead by Professor Gerhard Neukum (FU Berlin). The TMIS projects, beside providing a solid data management background of the huge datasets of the HRSC imagery and the derivative digital terrain models (DTMs) for the scientific research team, aimed at unconventional visualization, evaluation and automated extraction of selected Martian topographic features.

From HRSC images DTMs are created routinely at resolutions up to 50 m x 50 m per pixel. This resolution allows an automated recognition of the talus areas on Mars. Due to the difference in the surface evolution of Mars compared to Earth, the dominance of eolian and mass-wasting processes over fluvial erosion, the talus-like features are more frequent on Mars. The mapping of talus properties is therefore an interesting research goal.

Our contribution to the international collaboration intends to automatically recognize those pixels that most probably belong to the talus category. The developed method (first tested on Earth employing LiDAR topographic data) has been applied to the well-known meandering valleys of Nanedi Valles and the spectacular

Infobox

Project duration:

1 April 2007 – 30 September 2009

Coordinator:

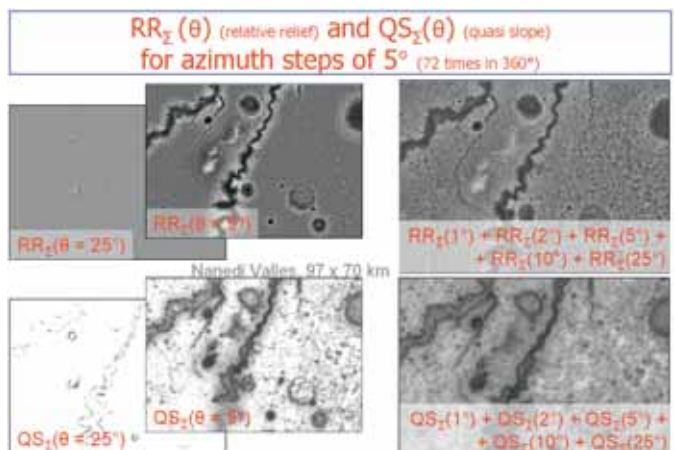
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area of West Candor Chasma, a northern extension of the famous Martian topographic mega-structure of Valles Marineris. The results show a good correlation to the visually recognizable talus features, and it facilitates a further analysis of these important surface elements.



Some unconventional visualizations of the HRSC DTM representing steps of the automated procedure for the recognition of talus surfaces.

Space Technology

μPPT

ACOSTA

CAFS

COMP-DAMAGE

Contamination Traps

CORD

DeGe

ECCS

E-FLEX

ENART

FALK

KeraSchub

LaserIgnition

MICO

NanoMatSpace

ProUST

RF-Suitcase

RPOD

SMDE

SVEQ-2

USI – Phase 2



AIT μPPT in operation.

The trend to microsattellites (wet mass ≤ 100 kg) and even nanosatellites (wet mass ≤ 1 kg) necessitates the development of miniaturized spacecraft components such as the propulsion system. Due to the small satellite mass and volume the general notion is that Electric Propulsion systems (EP) are the first choice for such satellites.

However, due to the very restricted available volume, mass, and power in particular for nanosatellites, the implementation of a propulsion system is very demanding and up to now there has been no propulsion system available for this task. Naturally, the difficulties increase with decreasing satellite size.

AIT initiated the investigation of the possibility to develop a propulsion system for small satellites in 2007. An initial assessment of existing (TRL ≥ 3) and proposed (TRL < 3) propulsion systems showed that a miniaturized pulsed plasma thruster (μPPT) is most beneficial and at the same time provides the highest probability to obtain a TRL of > 5 within a relatively short time.

Infobox

Project duration:

1 January 2010 – 30 June 2011

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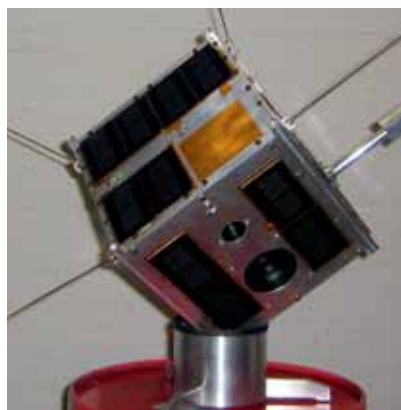
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Research at AIT has identified two major challenges, the limited lifetime of the ignition system and the size and volume of the electronic interface. Past projects proved that the ignition system lifetime is limited to a maximum of 15,000 cycles. Goal of the present project is to increase this to at least 250,000. The electronic components shall be implemented on a printed circuit board (PCB), which also contains up to four μPPT.

Presently, AIT has succeeded to design and test a battleship PCB and μPPT with a new and advanced ignition system. With this system the system lifetime has been increased to more than 100,000 cycles within the first 6 months of the project, an enhancement of more than 500 %. The picture above shows the AIT μPPT in operation. Further improvements of the lifetime are expected to be implemented until the end of the project.



CubeSat of the University of Graz, Austria.

Source: <http://www.tugsat.tugraz.at>

ACOSTA

Advanced Concepts for Structure Analysis of Large Lightweight Structures

The ACOSTA project intended to develop new tools for the numerical analysis and reliability analysis of large launcher structures. Its main work packages comprised:

- Domain decomposition/branching analysis
- Reliability and sensitivity
- New shell elements

While the tools were developed and tested on the basis of finite element models of the ARIANE 5 Front Skirt, it may be safe to assume that the results will be applicable for a wide range of problems in aerospace engineering. The company INTALES together with the participating institutes of the University of Innsbruck has acquired expert knowledge in these tasks and is on the way to the scientific leading position in aerospace engineering in this area.

Domain decomposition/branching analysis: Due to the splitting of numerical tasks in computing the behavior of the ARIANE 5 launcher among European participants, understanding domain decomposition is a must. Domain decomposition was successfully used as a pre-conditioner in iterative solvers. In the project, both domain decomposition and branching analysis were implemented into software codes, parallelized and tested in the branching analysis of buckling behavior.

Reliability and sensitivity: The approach of the project was that understanding reliability (e.g. to avoid buckling failure) can only be achieved on the basis of sensitivity analysis. For this purpose, a toolbox of sampling based methods was developed and successfully applied in the launcher as well as the engine nozzle in associated GSTP and FLPP projects. Sensitivity analysis tools range from Monte Carlo estimates of correlation measures input/output, resampling schemes for assessing their significance, ranking the input variables according to influence, tolerance intervals, random field models of material parameters, to acceleration of convergence of sampling based methods in iterative solvers. All these numerical tools have been implemented into independent software solutions.

Shell elements: Based on the need for modeling shells, intersections and stringers, improving the available shell elements has become a necessity. This also applies to the case of an improved branching analysis that requires the exact determination of bifurcation points. For this purpose, new solid shell elements were developed and successfully tested by means of standard and extended benchmark studies as well as the front skirt models.

Infobox

Project duration:

1 July 2008 – 30 April 2010

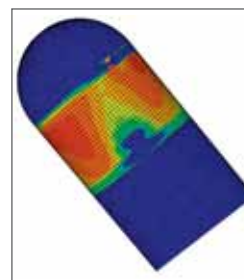
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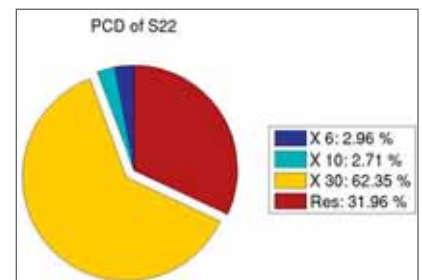
Partners:

University of Innsbruck
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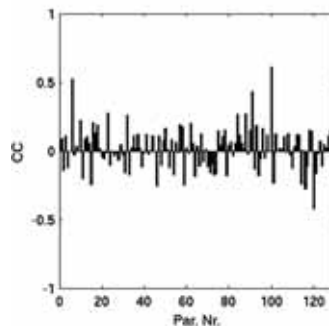
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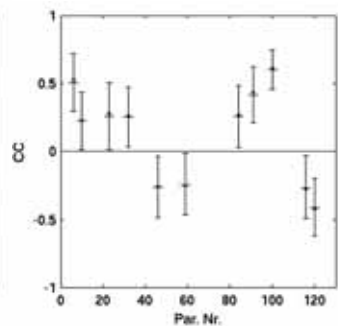
Front Skirt model: spatial distribution of stress influences.



Proportion of contribution of three important input parameters on a typical stress indicator measured in a linear metamodel.



Sensitivity study: correlation coefficients of 129 load parameters vs. typical stress indicator.



Sensitivity study: confidence intervals for the 11 inputs which were detected as significant.

In contrast to the digital ASIC domain, no space qualified analog ASIC processes and foundries are available in Europe. Thus, in order to achieve ITAR-free products, the use of commercial ASIC technologies and processes for space applications represents a highly innovative and attractive approach. However, the use of commercial non-space ASICs requires special design measures to achieve the required radiation tolerance on the one side and on the other side special measures need to be taken and application of rules are to be followed for the manufacturing and testing of the components. While RUAG Space GmbH (RSA) has already gained experience in the design area, the 'qualification' of the ASIC part is the substance of subject activity.

The challenging requirements for the qualification of an ASIC produced in a commercial ASIC foundry have been investigated selecting the qualification of the G3RF ASIC of our subcontractor Saphyrion (CH) as the test case of this study. The results are compiled in a handbook and templates, which summarize the know-how built up in this activity and shall facilitate development of own ASIC designs at a commercial foundry. Specific expertise has been acquired in the areas of foundry process, packaging, testing and radiation performance. Besides a survey of possible test and packaging houses, the handbook includes a chapter on lessons learned and precautions to be taken in future applications. The main goal is to optimise the cost function of such a commercial ASIC component qualification for space use by understanding all technological constraints. The results enable us to guide and support a subcontractor, which is inexperienced in space technologies, due to its background in the terrestrial market.

Infobox

Project duration:

1 January 2008 – 31 May 2010

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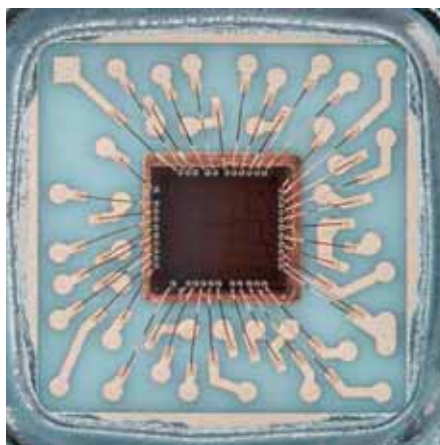
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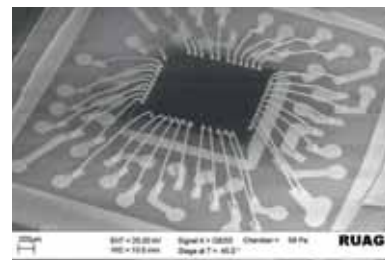
Our partner in this study, the Institute of Electronics of TU Graz, contributed its vast know-how of analog ASIC design, related ASIC foundries and applicable commercial quality standards. We compared quality standards applicable in the automotive and medical industry with the ESA quality standard in order to point out where the real differences are, which are to be considered.



View after destructive die-shear analysis.



Visual inspection of chip interior.



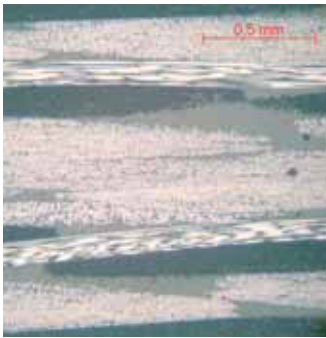
Electron microscope image for check of bonding wire clearance.



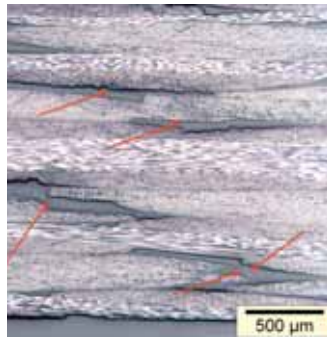
Electron microscope image of bonding detail.

COMP-DAMAGE

Damage Assessment of Fibre Reinforced Composite Materials Exposed to Cryogenic Environments



Material A – microscopic picture after 50x thermal cycling at LN2 temperature 50x magnitude no cracks visible.



Material B – microscopic picture after 5x thermal cycling at LN2 temperature 50x magnitude cracks visible, laminate failed at permeability testing (see the arrows).

Cryogenic media storage and transportation systems for cryogenic fluids as used for the Ariane 5 upper/lower stage are made of stainless steel and aluminum components respectively. Composite components bear a potential for mass and weight savings among other advantages especially when exposed to extreme environmental conditions. They are used for tank vessels/systems, lines, ducts, and mechanical interfaces.

On material level for cryogenic storage vessels design drivers are

- Pressure of the cryogenic fluid
- Vacuum between the inner and the outer vessel (thermal insulation)
- Temperature load due to the cryogenic liquid and the surrounding thermal environment (LHe)
- External mechanical loads

The residual stresses due to manufacturing and the superimposed thermal stresses in the matrix have to be considered, as they can result in micro-cracking of the matrix. These micro-cracks can lead to a deterioration of the vacuum by diffusion of the evaporated cryogenic gases and subsequently a deterioration of the thermal insulation.

The assessment performed in the frame of this work put focus on:

- Selection of proper materials/lay-up for the intended use
- Failure characterisation for temperatures down to LHe (4,2K/-269°C)
 - Shear
 - Tension/compression
 - Thermo-mechanical properties (thermal conductivity)
- Provision of a sound material database for assessing stress analysis as part of the development process
- Preparing the foundation for quality assurance related processes

Infobox

Project duration:

1 January 2009 – 31 December 2010

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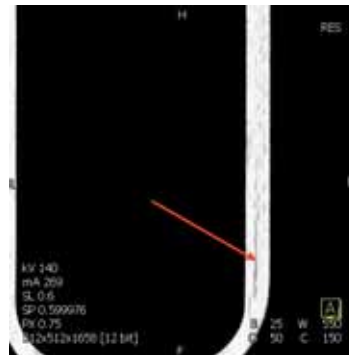
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X-ray tomographic picture of a composite tank.

Debonding in the 54 mm thick CFRP prepreg wall.

For this purpose, several samples were tested under cryogenic conditions until damage of the specimen was observed. These values were used to assess the results of a finite element (FE) or analytical analysis in terms of the actual margin of safety (MOS). Furthermore, non-destructive inspection techniques were assessed, highlighting their basic feasibility for the applications defined.

The following tasks were performed by our partner, the Austrian Institute of Technology:

- Manufacturing of the samples
- Material characterisation by means of several tests at room temperature and cryogenic temperatures concerning tension, compression, in-plane shear, coefficient of thermal expansion, thermal conductivity

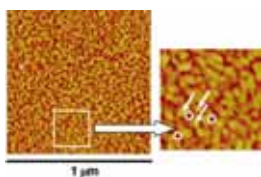
Contamination Traps

In-orbit Contamination Traps Based on Sol-Gel Coatings

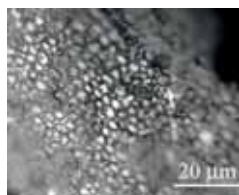
Control of molecular contamination for spacecraft is currently only pursued on ground. This is sufficient when the contamination levels at launch are significantly kept below end-of-life requirements. Due to increasingly sensitive optical payloads, even on-ground requirements become difficult to maintain leaving very little margin for nominal performance in orbit. Active control of contamination in orbit has already been demonstrated (e.g. at the Hubble Space Telescope) where zeolite-based cartridges have been placed near critical hardware. The drawback of this solution is a relatively small volume/surface ratio; the application of such a concept as coating would be most efficient.

In the project the feasibility of coatings as molecular contamination traps to protect optically sensitive or contamination critical payloads was investigated. The coatings were prepared by sol-gel processing. This is a wet-chemical technique, by which molecular precursors are converted to solid gels via colloidal dispersions, the sols. The precursors can be substituted by functional or non-functional organic groups, and inorganic-organic hybrid materials are thus obtained. Apart from the possibility to easily adjust the materials composition to the requirements of the anticipated application and to use simple deposition techniques, sol-gel processing also allows concomitant tailoring of other properties, such as porosity or optical performance.

Micrometer-thick, nanostructured hybrid films with very good adhesion to the housing materials were developed, which combined three levels of porosity (micro-, meso- and macropores), different metal centres (providing adsorption sites of different basicity and acidity) and multiple (functional) organic groups in one material. Macro-porosity was created by using self-assembled polystyrene spheres as templates or by the breath figure approach. Meso- and micropores were obtained by removing surfactant templates after film deposition. Different metal centres were introduced by using metal alkoxide mixtures. Organic groups with different polarity were incorporated either through organically modified precursors or by post-synthetic modification of the films.



Mesoporosity of the sol-gel films. The arrows point at solid particles, the spheres indicate the pores.



Macroporosity of the sol-gel films (from breath figure templating).

Infobox

Project duration:

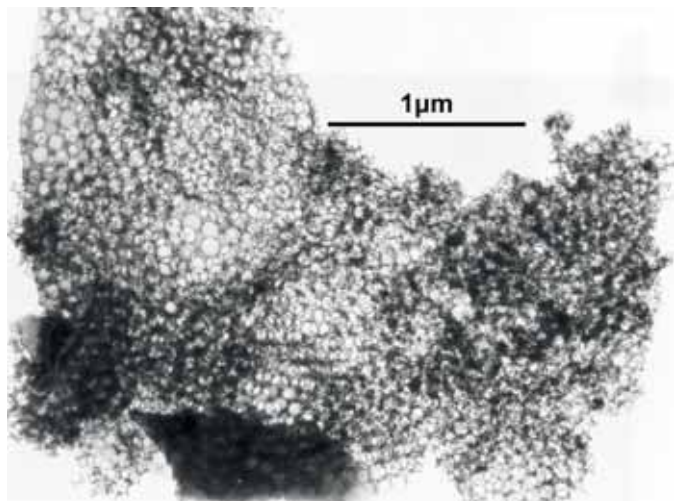
1 April 2008 – 30 September 2009

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Macroporosity of the sol-gel films (from templating with polystyrene spheres).

CORD

Commodity GPS Receiver Development

The CORD activity aims at preserving the competitiveness of RUAG Space in the context of GPS receivers for future missions by performing the delta developments necessary to obtain a commodity GPS receiver, compliant with most of the future precise orbit determination (POD) receivers' requirements. An analysis of the available information on future missions indicates that the SWARM GPS receiver developed by RSA has several peculiarities compared to more standard requirements of typical GPS POD receivers. The main changes that have been identified are required for the telecommand/telemetry interface and for the satellite power bus interface.

The need for MIL-STD-1553B was anticipated by RSA. As a consequence RSA has developed hardware and software required for establishing a MIL-STD-1553B interface within the frame of the ASAP 5 study Embedded Command & Control Subsystem (ECCS). However, the remaining delta developments indispensable for converting the SWARM GPS receiver into a receiver suitable for upcoming missions are still significant. The present activity allows RSA to take this important step on the way to a commodity receiver, which can be adapted to the requirements of future missions more easily.

In particular, generic GPS POD requirements have been determined. A DC/DC converter compatible with the standard power bus of low earth orbit satellites has been designed and successfully bread-boarded taking into account small differences in switch on/off commanding and ability to deliver increased power levels for future applications demanding somewhat higher power. Last but not least the processor hardware and software has been adapted to accommodate the typical MIL-STD-1553B command and control interface with emphasis on specification and implementation of the protocol of a general purpose packet utilisation standard.

The present activity is carried out in the frame of an international co-operation with RUAG Space AB (Sweden), an independent equipment supplier with focus on electronics products particularly experienced in the area of GPS receiver and antenna development. RSE, our valuable partner in almost all GNSS-related activities, contributes its antenna experience to the study and has optimised the antenna for multipath reduction. This antenna optimisation allows accommodating the antenna on different satellite platforms.



Dual-frequency GPS antenna optimized for multipath reduction

Infobox

Project duration:

1 November 2008 – 31 October 2010

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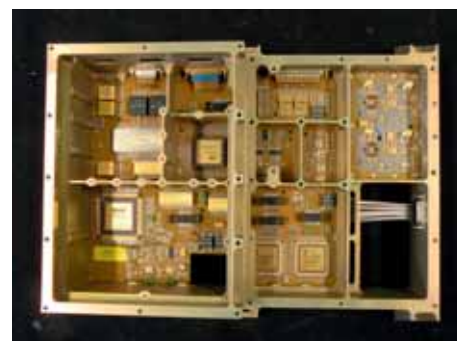
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Commodity GPS receiver



Commodity GPS receiver – processor board

DeGe – Deployable Getaway for the International Space Station (ISS)

Deployable Crew-Quarter-Cabin and Sleep-/Work-Equipment for Temporary Use on ISS and for Future Applications in 0-Gravity Environments

The research project “Deployable Getaway for the International Space Station” was conducted in the frame of ASAP 5 – concept initiative.

The Deployable Getaway (DeGe) is a deployable crew quarter, which can be unfolded into an astronaut’s crew cabin using a ‘folding box principle’. In folded configuration two of them can be stored in one International Standard Payload Rack on ISS. The size of the unfolded cabin corresponds to those of the crew-quarter cabins actually in use. In contrast to the integrated existing cabins the DeGe can be positioned at any suitable location on ISS.

Complementary to the crew cabin, an enhanced sleeping bag (Visitor Kit) was developed, which comprises features for “a sleeping mode” and “a working mode”. All these features can be applied on an individual base due to an add-on principle in order to allow for a personalized configuration of the equipment. The additional features for the sleeping mode comprise optional neck and cheek cushions, sleeping mask and noise-reducing headsets. For the working mode a lightweight mini desk can be attached in variable ways to create an individual workstation. The Visitor Kit can be adjusted in size and outfitted with bags for personal belongings. It can be used inside the Deployable Getaway or as an independent unit.

The main objectives are to improve habitability for crew exchange periods or short-duration missions and to provide flexible setups for long-duration missions.

For crew exchange periods or short-duration missions the Visitor Kit works independently as a temporary, lightweight equipment to ensure a minimum of privacy for crew members without

Infobox

Project duration:

1 April 2008 – 17 July 2009

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Deployable Getaway depicted on ISS in the Kibo Module. © Collage: LIQUIFER Systems Group/rendering: A. Stürzenbecher, background photo: courtesy of NASA



Working in the DeGe crew cabin. © Photo: Bruno Stubenrauch

personal cabins. For long-duration missions the goal was to facilitate the individual selection and location of private space for leisure time and breaks on ISS.

The concept can also be tested and adjusted on ISS for future long-duration stays in space and transfers to other planetary bodies such as Mars or for possible applications in space hotels.

The design development is based on personal interviews with astronauts, cosmonauts, and the team’s occupational health specialist.

1:1 functional mock-ups were built and tested in a 1-g environment. Further development and project enhancements have been planned. Currently, the team develops a corresponding furniture design to facilitate an individual work-break-rhythm in open plan offices on Earth.

ECCS

Embedded Command and Control System

The subject of this project was to design an embedded command and control subsystem (ECCS) as part of a satellite onboard electronics module based on the MIL-STD-1553B interface standard. In the present context "embedded" means that the subsystem is not implemented as a separate system formed by dedicated hard- and software, but that it is fully integrated into the extended hard- and software of an existing state-of-the-art spaceborne payload processor module.

As individual modules had to be modified, the design followed an innovative approach, which applied the so called qualification driven design (QDD) technique to achieve mutual isolation of the different entities of the modular design in order to accomplish true system component modularity and to avoid expensive re-qualification. This approach considers hardware, software and verification simultaneously for the purpose of arriving at a decomposition of encapsulated modules, ideally free of mutual interference.

Another important objective was to keep this development free of ITAR (International Traffic in Arms Regulations) limitations by careful choice of used components.

As final results of the proposed activity the following items are available for further usage:

- Embedded system design, implementing the MIL-Std-1553B interface standard for remote terminal operations
- MIL-Std-1553B conformance tester design
- Functional test facility
- Demonstrator, i.e. an operational payload processor breadboard with application software, tested for conformance

Both conformance tester and functional test facility are directly re-useable as part of flight-model production test equipment.

RUAG Space Austria performed this work in close cooperation with RUAG Space Sweden, who was responsible for the establishment of the facility for MIL-Std-1553 conformance testing, which is required for each produced flight item equipped with this interface.

The upper Picture shows the implementation of the ECCS in an avionics module for the Sentinel 2 satellite.

Infobox

Project duration:

7 January 2008 – 31 May 2010

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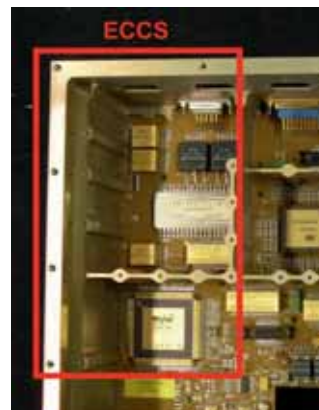
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ECCS Flight implementation. © RSA



Sentinel 2 Earth observation Satellite. © ESA

E-FLEX

ENGINE FLEXIBLES

For launchers different engine concepts exist (Fig. top, left). Depending on these engine concepts, requirements for engine flexible elements are different. The various engine concepts will be analyzed regarding their impact on lines/expansion joints requirements. The most severe requirements will be selected. In a first step elementary studies will be performed. These studies deal with material, coating, life time and vibration problems. Based on these studies, a draft design of a high temperature expansion joint will be elaborated.

The basic studies for engine flexible elements to be performed are:

- Materials suitable for high and low temperature expansion joints
Different types of materials, such as Fe- Co-, Ni-, Ti-based materials as well as others, will be investigated regarding their ability to use them as structural material and as material for bellows.
- Lifetime of high temperature expansion joints
Different methods exist to calculate the lifetime of bellows. The two most popular are the expansion joints manufacturers guideline EJMA Ed. 9 and DIN 14917. The two are analyzed and compared to finite element calculation of bellows as well as to test results known from other programs.
- Surface coating of movable elements
Surface coating shall reduce the friction of the movable elements. Especially for high temperature use the number of possible coatings is very limited. Wolfram disulfide, boron nitride, dicronite as well as Balinit Hardlube seem to be the most promising ones and show good high temperature resistance.
- Necessity of "flow liners" for high flow velocities
High flow velocities occur behind the preburners of gas generators or staged combustion engines. These high velocities can induce vibration into the movable elements (bellows) and considerably reduce their lifetime. Subject of this work is to analyze where the critical regions are and if methods exist to predict the vibration (eigenfrequency) with acceptable reliability (Fig. bottom).

Based on the elementary studies, a draft design of a light weight, high temperature expansion joint will be established. The design will be done for 100mm internal diameter expansion joint working at a temperature of 710K and facing a flow velocity of 280m/s. A very preliminary design of this expansion joint is given in Fig. top, right.

Infobox

Project duration:

1 January 2009 – 30 August 2010

Coordinator:

Magna Steyr Fahrzeugtechnik AG & Co KG

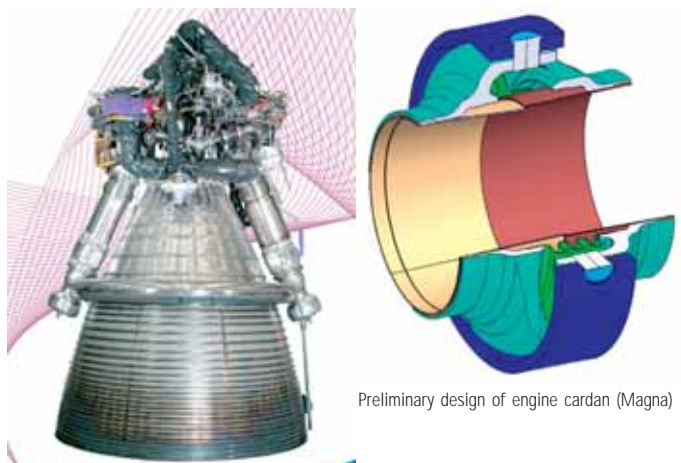
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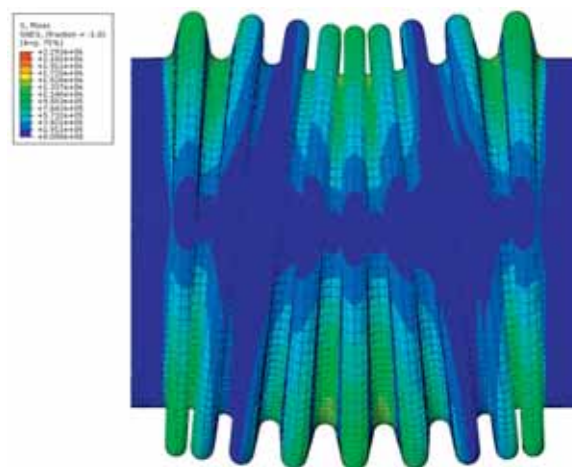
www.magnasteyr.com



Vulcain II – gas generator engine.

(Source: SNECMA)

Preliminary design of engine cardan (Magna)



Axial and lateral eigenfrequencies of bellows

ENART

Exploration of New Approaches to Real-Time Archiving of Satellite Data



Mission control room (example)

Scientific and Earth observation missions produce more and more data during their lifetime, supported by constantly increasing downlink capabilities. While this trend is highly desired from the mission perspective, it permanently creates a demand for even larger systems with even better performance in the ground segment.

The ground segment systems of space agencies, satellite manufacturers and satellite operators often cannot keep up with this steadily increasing amount of data and the required real-time performance for storage and retrieval (which again is influenced by a number of factors such as the choice of the hardware and database, the reading and writing mechanisms, the real-time capability of the operating system, back-up strategies and system distribution).

The experience from various space projects shows that the needs of satellite operations frequently exceed the capabilities of currently used tools and technologies. The main problems are: insufficient write performance (restricting the real-time capabilities in archiving of telemetry parameters), unsatisfying retrieval performance (restricting usability and availability of data), and huge disk space consumption (restricting operability and maintainability).

Infobox

Project duration:

30 May 2008 – 30 June 2010

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The goal of the ENART activity is to investigate and show in a prototype how fulfilment of the high-level requirements on data archiving, such as:

- (Near) Real-time write performance, without degradation of retrieval performance even if the archive is huge (several TByte or more)
- Powerful retrieval functions for analysis and evaluation of historical data
- Efficient support of low-level data types as for example raw octets or bit strings
- Application of data reduction / compression to optimise disk space
- Support for parallel writing and retrieving
- Non-functional requirements such as reliability, availability, safety and security

as imposed by space data systems (such as mission control systems, carrier monitoring systems, check-out systems), can be improved by alternate approaches to structuring, indexing, storage and retrieval algorithms (e.g. optimisation of data structures and algorithms due to specific properties of the data, use of structural approaches such as Patricia Tries / Radix Trees).

Benchmarking against existing (COTS) solutions and an analysis of integratability into existing systems and interfaces complete the work in the ENART project.

FALK

Fault Aware Light Weight Micro Kernel

The control of electronic platform equipment or of instruments on satellites usually requires the use of microprocessors. If the applied control algorithms are more complex, the use of a real-time operating system facilitates the concurrent execution of the different tasks and thus the coding of the necessary software.

The need to qualify any software used in space missions asks for the source code of the used operating system. Existing non-space operating systems rarely follow strict coding standards (which is state of the art for space applications). Furthermore, the underlying program codes are usually very large, which requires a tremendous qualification effort.

For these reasons RUAG Space GmbH (RSA) decided to design its own small operating system, called ARTOS, a kernel, that covers all basic functions of an operating system and that can be easily qualified. The features of the operating system are that test coverage of 100 % is made possible and that defensive programming is heavily used in order to meet the requirements for mission critical software. On top of that the design should be such that data races cannot occur in the operating system code (see picture 1 race conditions test setup).

The market potential for the kernel consists in its use in RSA on-board electronic equipment, which facilitates the programming of microprocessors (see picture 2, target processor) for RSA, and in the promotion of the kernel to other space companies. The code will be made available to the space community free of charge as open source, support for the programming of the board support package and the qualification of the software will be offered by RSA.

Infobox

Project duration:

1 February 2008 – 31 May 2009

Coordinator:

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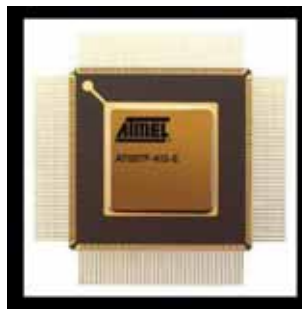
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Partner:

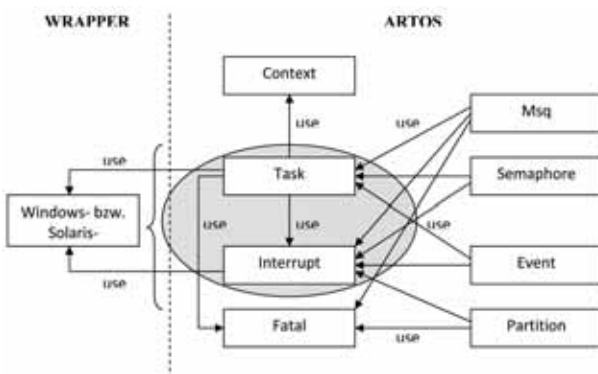
Gaisler Research AB, Göteborg, Sweden

Jiri Gaisler

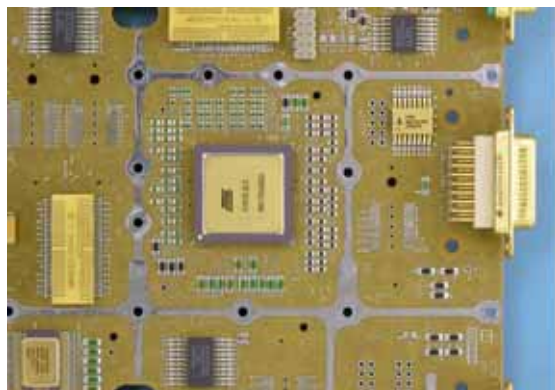
www.gaisler.com



Target processor ATMELEON 2.
© ATMELE



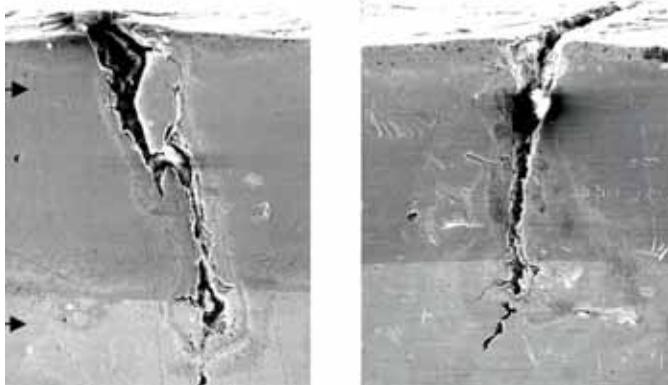
Race conditions test setup



ARTOS test board

KeraSchub

Feasibility Study of Regeneratively Cooled Thrust Chambers Made of C/SiC Ceramic Composites



Metallic rocket engine chamber wall cracks

The thermo-mechanical loads in the combustion chamber wall of high performance liquid propellant rocket engines are beyond the elasticity limit of the best metals available today. Even those rocket motors with the longest service life, the Russian RD-170/180/190, are limited to only 20 flight cycles. Generally, more than 50 % of all launch failures are caused by the propulsion system (Fig. right, top).

Metallic materials appear to have reached their technological limit. For several decades now, little or no improvements have been achieved with respect to service life, flight cycles, reliability and safety. However, steady progress has been made in the field of ceramic matrix composite (CMC) materials and in particular carbon-fiber reinforced silicon carbide (C/SiC). Although C/SiC CMC's are in operational use today, very high production costs remain a key constraint for space applications and even more so for any other potential mass markets. For this reason, non-space related material research has been focused on developing methods, which allow a significant reduction in production costs, in recent years. As a result, a first mass market introduction is starting in the field of C/SiC car disk brakes.

The KeraSchub study has analyzed whether such cost-efficient C/SiC materials could also be used for the design of rocket thrust chambers. The main question being: Can a rocket thrust chamber be designed with such cost-efficient materials? The KeraSchub study has performed a material survey and investigated conceptual thrust chamber designs based on these materials. It was determined that deficiencies of cost-efficient materials can be overcome by clever thrust chamber designs. As well as a reduction in cost and an increase in lifetime, a significant increase in reliability and safety can possibly be achieved.

Infobox

Project duration:

1 May 2008 – 31 October 2008

Coordinator:

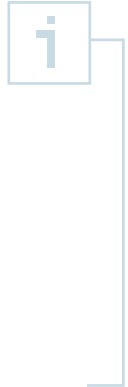
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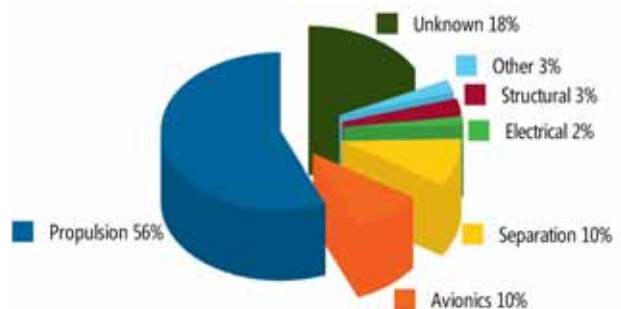
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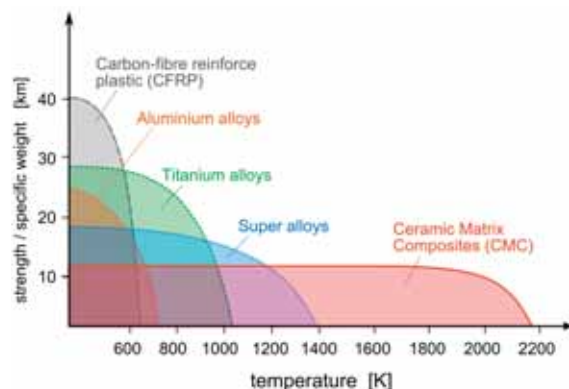


KeraSchub is an example of simultaneous technology spin-in and spin-off. Rather than considering space R&D as an isolated discipline, existing non-space technologies are used for space applications and the resulting advanced know-how can be spun-off to non-space applications. In the case of KeraSchub for instance, these are industrial high temperature heat exchangers.

For the next step, representative ceramic samples tests are proposed in ASAP 7, in order to confirm the very encouraging theoretical results of KeraSchub.



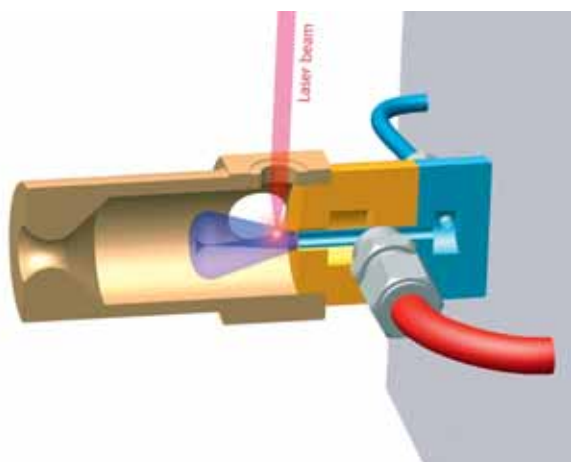
Launch vehicle failure causes. [Source: Chang]



Specific strength over temperature for various materials

Laser Ignition

Feasibility Study of Flight Weight Laser Ignition Systems for Liquid Propellant Rocket Engines



Conceptual view of a test chamber for laser ignition

Laser ignition systems are undergoing a dynamic development in the fields of automobile and large combustion engines and have reached the stage of advanced prototypes. Creating an ignition spark in a desired location in space rather than close to the cold walls results in cleaner combustion, higher engine efficiency and lower emissions.

Laser ignition is very attractive for rocket engines and has in fact already been applied on test stands for its precise and perfectly reproducible ignition characteristics.

Laser ignition could be the key to simpler and more reliable rocket engines. The complex and heavy torch ignition systems would become altogether unnecessary in large booster engines. For smaller rocket engines, laser ignition could enable the use of non-toxic propellants in order to replace the highly toxic and carcinogen hydrazine-based propellants commonly used in launch vehicle upper stages and satellites.

With a heritage of more than ten years in laser ignition development, the Photonics Institute can be counted to the world leaders in this field. In order to capitalize on this strength in the field of spaceflight, the project LaserIgnition assessed whether laser ignition systems for liquid propellant rocket engines would be technically viable in the coming years. The key question is, whether the design of laser ignition systems of compact size, low mass and low power consumption is feasible.

To this end, rocket ignition system requirements have been defined and key laser components identified and analyzed. System concepts based on different ignition methods, such as ablative (LAI) and plasma ignition (LPI) and others, have been determined, compared and evaluated, in order to identify which

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Project duration:

1 December 2008 – 30 September 2009

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components and ignition system concepts would be the best candidates. Two very promising system candidates have been identified and in view of the rapid progress in laser development, in particular laser power density, the result of the study is extremely positive.

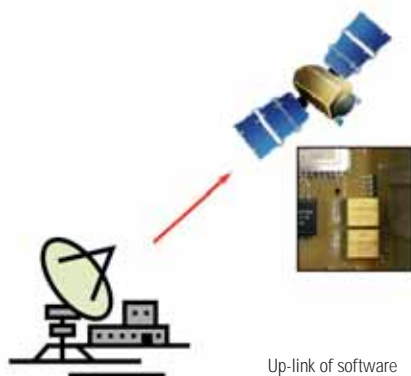
For the next step, practical tests are considered indispensable, especially to obtain practical values for the minimum laser pulse energy required for reliable ignition.



Laser spark plug developed at the Photonics Institute

MICO

Mission Critical Controller



In many space applications the mission critical controller (MICO) is a key element of the satellite control system. Among other functions, such a MICO offers the possibility to load and update software to the satellite (Fig. top) without SW support onboard. RUAG Space GmbH (RSA) has developed a controller board for space applications, intended to be used as "standard controller" in future projects. This board is based on the Atmel AT697 LEON2 fault tolerant processor and is equipped with a MIL-STD-1553B remote terminal control interface. However, in its present form the board does not allow for direct SW update (without software intervention) via the control interface, hence it cannot be used for mission critical applications.

The aim of the project is to theoretically derive and design an innovative fault tolerant controller function for mission critical applications to be introduced into the already existing processor module. The implementation is entirely accomplished by modifications/augmentation of the processor module printed circuit board (PCB) and/or the (existing) processor module field-programmable gate array (FPGA), referred to as ECOM FPGA. Physical dimensions of the board as well as FPGA size and footprint are foreseen to remain unchanged.

The present study focuses on an assessment of the needs of possible users such as the European Space Operations Centre in Darmstadt and the choice of the adequate concept to be implemented. Prof. Andreas Steininger of the Institute of Computer Engineering of the Vienna University of Technology was strongly involved in this latter task.

In a next step the mission critical controller is planned to be incorporated into the existing RSA controller PCB-design as well as into the design of the ECOM FPGA. The results of this study will be the baseline for later use and success in operational programs, allowing to provide embedded onboard systems at lower cost, within a shorter time frame and with better performance than competitors.

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Project duration:

1 January 2010 – 31 October 2010

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European Space Operation Centre. © ESA

NanoMatSpace

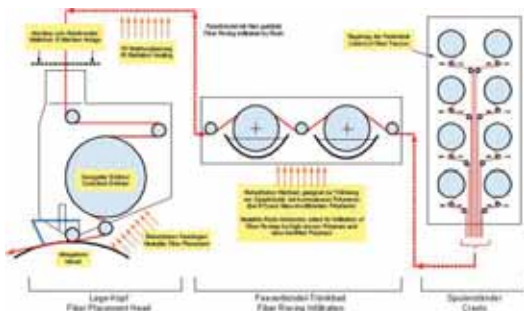
Nano-Composites and High-Performance Materials for Space

The concept study of "Nano-composites and high-performance materials for space", NanoMatSpace, was worked out in order to evaluate the possibilities and potentials in Austria in the area of high-performance materials for future application in space. Special attention was put on the technology maturity level of new materials and of high-performance materials, particularly that of nano-composites.

Why do space projects require new materials? On the one side, there is a continuous need for further improvement of structural composite materials. Extreme lightweight construction is mandatory. Furthermore, such structures have to be designed in accordance to utmost dimensional stability and thermoelastic stability requirements for many applications. On the other side, advanced functional materials are also needed. In particular, designers of space mechanisms look for new materials showing enhanced properties – for example, for the construction of high-grade long-life bearings that are exposed to the harsh environment of space dominated by large temperature variations and high radiation densities.

One main part of the study NanoMatSpace presents typical applications for space transportation, satellites, platforms and instruments, which require enhanced materials with improved properties to meet requirement specifications. The other main part of the study concentrates on evaluating and assessing the actual status of material technology in Austria in close cooperation with national institutes and industry.

As the result of a comprehensive investigation, a number of promising material technologies were identified as already being established in Austria, which imply a strong potential for further development of "space materials" for application in future space programmes. The essential outcome of the study NanoMatSpace was that amongst the prospering material technologies established in Austria, one of them, namely the polymer composite technology, has reached a high level of know-how and infrastructure and would therefore provide an excellent basis for further development of advanced (nano-modified) polymer composites.



Fabrication of advanced (nano-) composite structures by application of modified fiber placement technique

Infobox

Project duration:

1 October 2007 – 31 August 2008

Coordinator:

Space Technology Consultancy Vienna

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The following evaluation criteria were applied for the selection of the most favourable material technologies for space application:

- Specific experience and know-how in the special technology area looked at
- Opportunity of application in near-term European space projects
- Existence of technological infrastructure including quality control measures to establish process modifications, avoiding large economical investments for installation of new process routes
- Easy access to raw materials, avoiding import limitations and single sources of delivery
- Diversification potential of Austrian material technology to other non-space industrial applications and its significance to national economy and its expansion

The results of the study "NanoMatSpace" were also presented to ESA in the frame of an invited presentation on technological capabilities in Austria in the autumn of 2008.

Recently, a selected consortium of industry and research has been joined to bid for a follow-up project in the frame of the Austrian ASAP 7 programme. Objectives of the project entitled "Advanced Composite Technologies for Extreme Light-Weight Space Structures, ACTRESS", which has been accepted for funding, are to demonstrate Austrian capabilities for the whole process chain for advanced composite technologies at a high technology maturity level.

ProUST – a “Guardian Angel” for Satellites

Protection Unit for Satellite Testing

A nightmare scenario during assembling and testing a satellite is that it could be damaged due to malfunction or operational error and lead to mission delay and exploding costs. This risk especially occurs at the power subsystem such as solar array interfaces or onboard battery.

Siemens' Power Special Check-Out Equipment (SCOE) product line contains a proven dedicated safety system, which reacts within microseconds to any anomaly and shuts off power.

Due to rising power demand in spacecraft and related test equipment the protection unit was designated for an upgrade. It had to address several severe requirements at the same time: higher voltages, higher currents, more channels, more flexibility, smaller size (factor 10), and, of course, lower cost.

New features were added such as smart diagnostic capabilities for documentation and quick analysis of events (effectively a 60-channel scope).

The essential challenge to the engineers was stretching electronics to the limit without taking a risk in reliability and trustworthiness.

The investigative approach explored multiple technology trends:

- State-of-the-art platform FPGAs for complex custom digital logic, including a powerful microprocessor for embedded software:
- Isolated sigma-delta modulators for miniaturisation of analogue measurement
- Leading-edge Power-MOSFETs allow fast reaction and dense packing



Boulevard of electronics *)

Infobox

Project duration:

1 April 2009 – 30 June 2009

Coordinator:

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Pizza box front view *)

- The technology mix comprises the best available reed and safety relays
- All devices get connected by sophisticated PCB technology capable to combine high currents with fine-pitch ICs

Efficient manufacturing and thorough testability can not be traded-off and were a focus of research.

Even the mechanical side needed innovative solutions.

Fit into a flat 19" "pizzabox" format, the power dissipation must correspond to a tailored thermal management. An additional constraint are the extreme vibrations during operation at the launchpad, which require a robust construction.

A milled aluminium base plate acting both as housing and heat sink, a steel cover with redundant radial fans mounted to it and a transparent front panel compose the rugged box, which is made of only a handful of ingeniously shaped parts.

One subtle detail tells the expert how extraordinary the result is: 138 independent voltage domains on a single PCB set a new record – far above any consumer electronics you can buy. A key customer initially assessed the product concept as a "dream". In the follow-up project GPSCOE (Generic Power SCOE) in the frame of the ESA GSTP programme, this dream has become true.

*) The ProUST concept has been realized in the follow-up GSTP project "Generic Power SCOE" (GPSCOE) as Multi-Channel Protection Module MCPM.

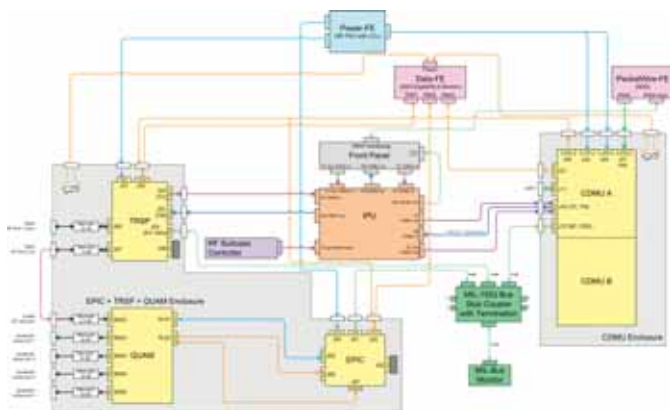
RF-Suitcase

Generic RF-Suitcase Core

So called Radio Frequency Suitcases (RF-suitcases) are required for every spacecraft, in order to assure compatibility of the spacecraft and every groundstation delivering support to the mission. An RF-suitcase contains a simplified, yet representative configuration of the satellite flight hardware in order to make these tests representative.

The Generic RF-Suitcase core aims at procuring a generic platform that facilitates integration of hardware modules of different missions in a cost- and time-efficient way. By that, the proposed activity shall strengthen the position of the Siemens Space Business Unit in its major core business and shall help extending our Electrical Ground Support Equipment (EGSE) and satellite test system product portfolio with a new product element: Just like all our other portfolio elements, such as EGSE systems (RF & Telemetry, Telecommand and Control (TT&C), Specific Check-Out Equipment (SCOE), Power & Launch base SCOE, Core EGSE, and Payload EGSE), the Generic RF-Suitcase will constitute the baseline for our future mission specific RF-suitcase turn-key solutions.

Offering a generic product as the baseline for the mission specific turn-key solution is essential both for winning the contract for a mission specific solution, and for implementing the project within time and budget and at the requested technical quality level. This approach significantly reduces the technical risk, schedule risk, and the overall cost.



RF-suitcase – interconnection

Infobox

Project duration:

1 September 2009 – 30 June 2011

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Ordinary RF-suitcase designs tend to be completely mission-oriented and therefore strictly mission specific, while the ASAP 6 activity focused on:

- Re-use as many hardware and software parts as possible
- Provide a high degree of flexibility between missions through synergies with our ASAP 6 project ProUST (deploying an Field Programmable Gate Array (FPGA)-based approach for all digital interfaces required within the Generic RF-Suitcase core)
- Provide generic support for analogue interfaces
- Support adaptation through configuration
- Provide a software framework for configuration and execution (supporting all required configuration, control and monitoring activities) by massively exploiting our heritage of TT&C/RF-SCOE systems (test procedures, database and graphical user interface)

This ASAP 6 activity is executed in cooperation with an SME, namely with Alexander Kerl Service (one-person company). This company is in charge of the elaboration of the generic analogue interfaces concept, as well as for cabling harness design and construction.

We expect that the proposed ASAP 6 activity Generic RF-Suitcase core infrastructure will put Siemens in a position to submit competitively priced offers for RF-suitcases without sacrificing quality or credibility, allowing Siemens to provide RF-suitcases for the European Space Agency (ESA), the German Aerospace Center (DLR) and commercial telecoms missions.

RPOD

Real-Time Precise Orbit Determination

One key component of any GNSS receiver is the navigation solution, i.e. the determination of position, velocity and time. It can be observed that for the GPS receiver applications, which are in the focus of the RUAG Space product development, the real-time navigation solution has evolved from a basic feature, which allows for autonomous operation of a stand-alone instrument, to an element being crucial for the complete mission. The evolution of the respective performance requirements became so stringent that they go beyond classical navigation and require precise orbit determination (POD) in real-time, already onboard the satellite.

RSA defined and implemented a real-time navigation solution in the MetOP GRAS project, where the position requirement was 100 m, and refined it in successor projects, where the requirement was tightened to 20 m in the three dimensions. Although, this advanced navigation solution already shows a very good performance, the required position, velocity and time (PVT) accuracy of missions currently being developed, and planned, respectively, exceeds the performance capabilities of the first RSA implementation.

The present activity supports RSA's on-going GNSS receiver product development and aims at establishing real-time navigation algorithms, which enable the RSA receiver to reach a navigation performance in the range of one meter.

A very fruitful cooperation with the Institute of Navigation and Satellite Geodesy of the Graz University of Technology, which disposes of an internationally acknowledged know-how on precise orbit determination and satellite navigation, has been established.

In order to meet this overall target several prerequisites and accompanying measures had to be accomplished. An assessment of the main error sources and their actual magnitude was performed. For high-end receivers the GPS system errors are the dominant errors, which, however, have decreased over the last years. In order to determine the actual navigation performance of a selected algorithm, it was necessary to have justified assumptions on the GPS error. Furthermore, a validation environment has been established, which provides the possibility to quantify the actual performance. An enhanced navigation algorithm was then identified and tested, which can be implemented in real-time receivers with the next generation of space qualified processors.

Infobox

Project duration:

1 February 2008 – 30 June 2010

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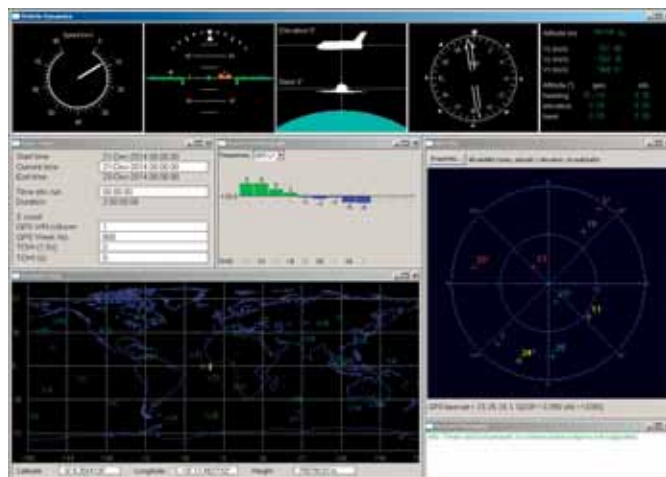
Partner:

Graz University of Technology

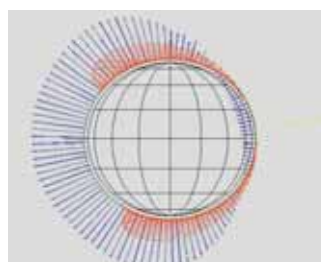
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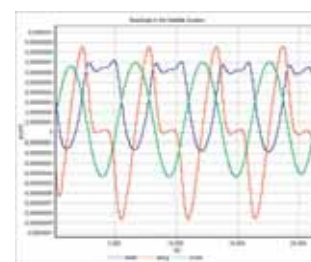
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GPS simulation environment



Solar radiation pressure related forces on an Earth orbiting satellite



Residual forces comparing algorithm force model and GSS simulation

SMDE

Spaceborne Motor Drive Electronics

Onboard of satellites many subsystems comprise mechanisms that serve either to secure the functioning of the platform, such as solar array drive mechanisms and thruster pointing mechanisms (example see picture) or to support the operation of the payload, such as deployment systems, antenna position systems, high-speed pumps etc.

The objective of this study was to assess the requirements of past and near future space missions and to conduct a technology and topology survey. The results of this survey allowed selecting concepts for power electronics building blocks, with the help of which spaceborne motors, that drive different kinds of mechanisms, can be controlled.

Moreover, the electrical subsystem comprising motor and electronics was studied in detail by choosing a specific motor and analyzing the drive electronics in view of avoiding oscillations and shocks in the system. The generation of smooth control signals for motor movement is of high importance in order to increase the performance of the unit.

For this purpose, the Institute of Electrical Drives and Machines of the Vienna University of Technology supported RUAG Space by building a simulation model based on measurements of a real two phase permanent magnet stepper motor.

The model is used to simulate the motor dynamics as accurately as possible, in order to optimize the design of the drive electronics. It is further used to test different drive design concepts and to find the most promising approach for future projects.

Infobox

Project duration:

1 January 2010 – 30 December 2010

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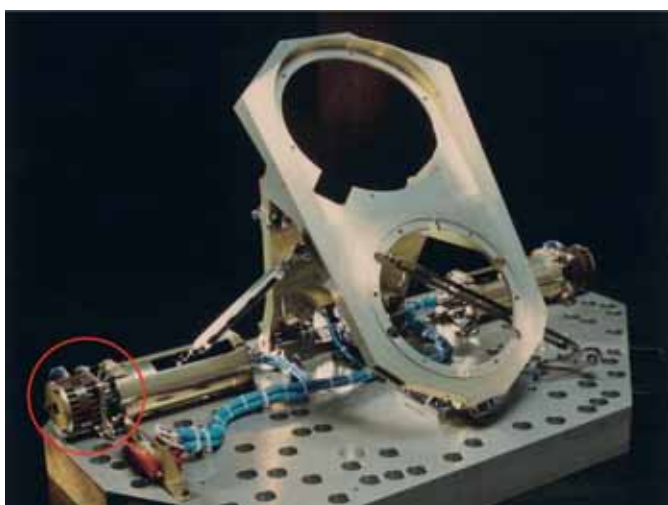
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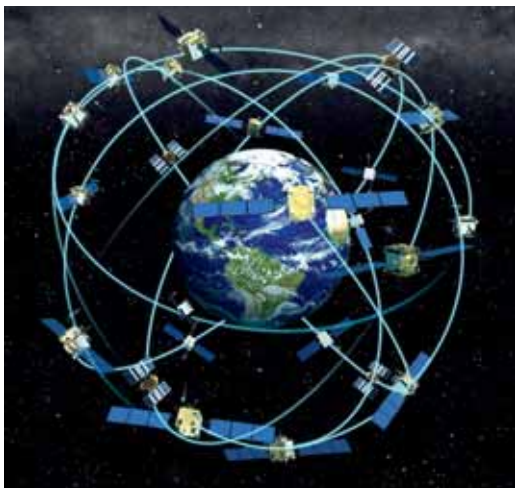
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Motor driven thruster pointing mechanism. © RSA

SVEQ-2

GNSS Receiver SW Verification & Qualification Framework – Phase 2



GPS constellation

The present activity is the follow-up of a study already performed within ASAP 4. The first part, concentrating on the simulation based software qualification platform, was successfully finished. The second part comprises the remaining activities, mainly the target based software qualification platform, i.e. hardware in the loop testing and qualification.

Both phases together aim at supporting inevitable product evolution by providing a framework for software verification and qualification, implementing it into our GNSS-receiver software. The need for such tools has been emphasized in the mean time by the differing software requirements of the various Sentinel missions even for a so-called 'recurring' GPS receiver.

This activity is part of our product development program, aiming at the establishment of a product line of spaceborne GNSS receivers. Our strategy is to apply a synoptic view to all applications and to develop receiver components such and at such level that they can be applied to all space applications and that they allow for continuous, but gradual receiver evolution in line with technological progress and with the evolution of satellite navigation services. Apportioning component non-recurring costs to all applications is the only way to arrive at competitive products.

All elements of a GNSS receiver are ultimately united by the receiver software. Almost each and every hardware and/or system change will have software modifications, which comprises design, implementation and test, as a consequence. The effort to test and qualify spaceborne software systems with these stringent requirements in terms of functionality, reliability and maintainability typically make up about 50 % of the complete software development life-cycle.

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Project duration:

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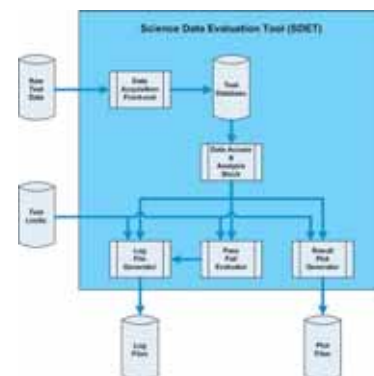
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The overall development activity of the GPS product line is an international cooperation between RUAG Space AB of Sweden and RUAG Space GmbH (Austria) being responsible for the precise orbit determination line. This cooperation builds on the respective technical expertise of the two companies in the radio frequency and digital processing area, respectively.



Hardware in the loop testing



Architecture of the science data evaluation tool (SDET)

USI – Phase 2

Non-flammable Super-Insulation (USI) – Phase 2

Based on the multi-layer insulation technology for spacecraft, this technology transfer project about non-flammable super-insulation focuses on the development of a novel, inert multi-layer thermal insulation, which satisfies the applicable requirements and standards for cryogenic vessels used for storage and transport of liquefied technical gases such as He, Ar, N₂ and O₂, with respect to oxygen compatibility.

The cornerstones for the project were prepared in phase 1. Using the now well defined requirement specifications for different applications and considering the necessary adaptations to the needs of major cryogenic device suppliers, USI Phase 2 featured an ambitious test program.

The scientific partners, the Austrian Research Institute for Chemistry and Technology (ofi) and the Institute of Applied Physics of the Vienna University of Technology, contributed their strength in the fields of chemistry, physics and the theory of combustion, extinction and fire dynamics.

New ultra-light spacer materials were employed to reduce the influence of absorption between reflective foil layers in the spacer material and thus increase the insulation efficiency. Specialized glass fiber materials without organic content were identified and used. All new materials were tested with calorimeter measurements for insulation efficiency and with drop tests in liquid oxygen for oxygen compatibility and non-flammability according to international standards.

Gas flows through narrow gaps filled with novel spacer material were measured and the possible impact of residual gas in super-insulation packages was determined.

Alternatives to non-flammable super-insulation were investigated:

For surfaces at very low temperatures (e.g. 4 Kelvin at helium cryostat surfaces), a new and more robust laminate material was successfully developed and tested.

Simulations using generic algorithms for optimization of the mechanical spring elements employed in whole-metal-insulation concepts improved the theoretical performance considerably.

Infobox

Project duration:

1 February 2008 – 31 January 2010

Coordinator:

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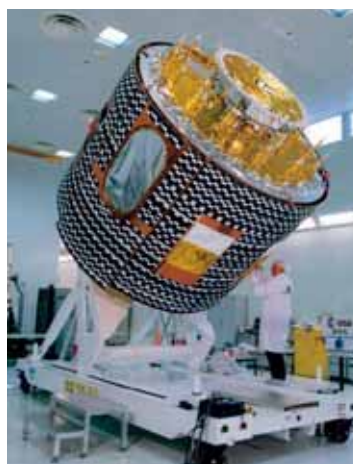
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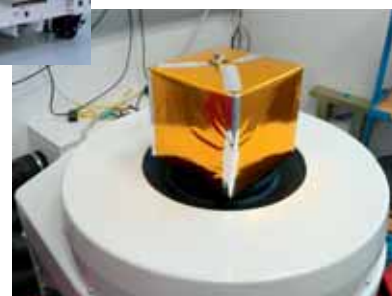
Austrian Research Institute for Chemistry
and Technology (ofi)

Martin Englisch

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Satellite mounted on trolley.
© ESA



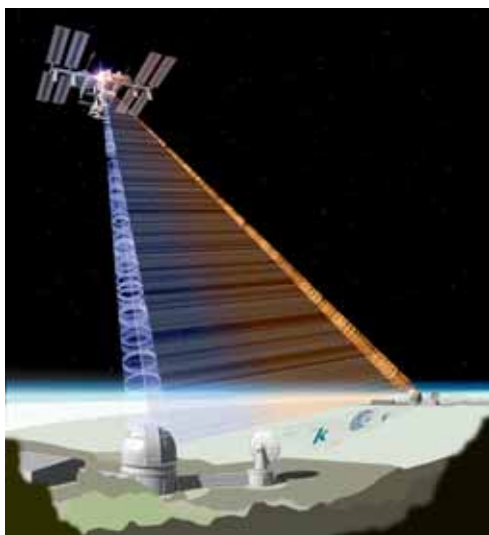
Super-insulation mounted on vibration
test facility. © RSA

Telecommunications

QCS

TelcoPTS

VSAT



Proposed quantum communication experiment in space.

Quantum mechanics makes a number of predictions, that are in stark contrast to our intuition of the world around us. The most essential ingredient of these counterintuitive predictions is entanglement (correlations between particles), a property of groups of particles that exists independent of their spatial and temporal separation. Entanglement can be used to show that any 'intuitive' theory (where the properties of particles are well defined and interacting particles exchange some force) is not consistent with the world. Up to now no one has conclusively shown this. Entanglement must also be tested over length scales far beyond current laboratory experiments to check the universal validity of quantum mechanics. The work presented here is an important stepping stone to a proposed Space-QUEST mission, which would utilise satellites to make such experiments possible.

In this experiment entangled photon pairs were created on La Palma, Spain. Then, one of these photons was sent to Tenerife, 144 km away. Additionally, random numbers were generated on both islands so that the way the correlations of the entangled photons were measured was independent of the photons. The spatial separation and timing of these actions was precisely arranged to show the counterintuitive nature of our world. Although this work does not completely rule out any 'intuitive' theory it is the single most conclusive experiment of its type at the present time.

The counterintuitive features of quantum mechanics are not only of theoretical interest, they can be used to for tasks, that would otherwise not be possible, most notably quantum cryptography (the sending of information in an absolutely secure way) and quantum computation (solving problems using quantum

Infobox

Project duration:

1 January 2008 – 31 December 2009

Coordinator:

Austrian Academy of Sciences

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Here the receiver telescope used in this ASAP project is shown, located on the Canary Island of Tenerife.

systems). The technology created to complete this work can be used to directly aid research in these fields and also serves as a proof of principle for future experiments in space. Such experiments would both allow quantum tasks to be distributed throughout the world and also open the door for a new generation of experiments on a scale far beyond the capabilities of any earth-bound experiments.

The work presented here was possible due to a number of national and international collaborations and support, most notably with the help of the Austrian Research Promotion Agency (FFG).

TelcoPTS

Generic Telecom Payload Test System

Astrium UK in Portsmouth has a long-term experience in building telecommunication payloads. The current Astrium telecom payload test system (TelcoPTS) is project-specific and therefore requires the re-procurement of the PTS for each payload. Furthermore, the existing Astrium TelcoPTS lacks a generic and automatic test sequence execution system. Hence, for each payload Astrium has to re-implement the payload test procedures by itself. This makes the current TelcoPTS solution very expensive and, what is even more important, extremely time critical, as the test system provisioning may even delay the AIT/AIV of the satellite's payload. This is an unacceptable situation in the time critical commercial Telecom payload business, where late delivery is subjected to high penalty payments!

Moreover, Astrium and other telecom payload manufactures expect new and more business opportunities with respect to more complex telecom payloads. These new complex systems will cause new AIT needs and therefore will pose new challenges for the TelcoPTS.

As a consequence, Astrium plans to refurbish the existing telecom payload test system with a new generic TelcoPTS capable of meeting the new AIT needs for mobile telecom satellite and spot beam payload projects (multi-spot-beam and mobile telecom satellite). This new generic ASAP 5 TelcoPTS will be the baseline for most of the future telecom payload test systems. Since Astrium manufactures at least 4-5 telecom payloads each year, the contract for the generic Astrium TelcoPTS is of high strategic and long-term commercial importance for Siemens.

Generating of multicarrier signals required for testing mobile payloads on Alphasat and TerreStar is crucial for testing under realistic conditions. Nevertheless, several aspects of such stimulus signals demand specific attention. In particular the following key requirements on the multi-carrier signal generation drive the process of selecting the right combination of measurement hardware and preparation software:

- The wide required maximum bandwidth
- The maximum number of individual carriers to be simulated (e.g. 75000 for each source for Alphasat)
- The flexibility with respect to the carrier frequency ranges for the mobile and feeder uplink (in L-band and C-Band for Alphasat)

The solution for the generic TelcoPTS was implemented together with TU Graz and is in use at the Alphasat RMS Test system delivered to Astrium UK in April 2010.

Infobox

Project duration:

1 July 2008 – 30 April 2010

Coordinator:

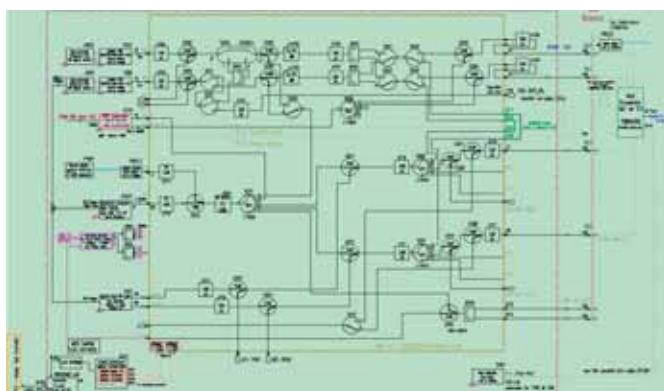
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Alphasat RMS block diagram



Alphasat RMS rack

VSAT

VSAT Monitoring System



VSAT commissioning

The physical RF link of VSAT stations, especially the quality of the MF-TDMA return link, is crucial for ensuring high quality satellite communication. An accurate aligned antenna minimizes interference and secures the best physical way of maximizing the Bit/Hz/Year ratio.

The SIECAMS VSAT monitoring system allows terminal per terminal measurement of RF quality parameters dedicated to MF-TDMA traffic transmitted from VSAT satellite networks without service interruption.

Benefits of VSAT monitoring:

- Automatic measurement of cross-polar isolation on terminal level
- Alarm generation in case RF quality parameters are beyond requirements
- Minimizing interference risk by detection and identification of cross-polar leakage on terminal level
- Minimizing OPEX in an ACM network showing bad aligned antennas not utilizing the potential maximum physical transmission link rate (Bit/Hz/Year)
- Permanent or on demand check of RF-link quality on terminal level without service interruption
- Identification of "quick and dirty" installations

RF-check only at installation

Usually, the correct alignment of the antenna is only verified during the pre-transmission line-up phase when accessing the satellite for the very first time. The standard alignment method requires the installer to transmit a test signal (usually a CW signal), which is measured in terms of power and polarization discrimination by the satellite control centre.

Once the VSAT is in operational service, several occurrences (weather conditions, soil erosion, vandalism, construction work,

Infobox

Project duration:

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hardware failure, etc.) may lead to antenna misalignment situations causing performance degradation and, even more important, potential interference due to cross-polarization leakage to services transmitting in the opposite polarization.

The challenge

Due to the nature of MF-TDMA traffic, it is a challenge for the service provider to identify misaligned terminal(s) in the network. One possibility is the "clearing the uplink" approach, which means to switch all terminals into CW mode and repeat the polarization discrimination and RF parameter measurement in a similar way as it is done during the line-up phase. But this is a time-consuming task and requires the interruption of operational services.

The Solution

The SIECAMS VSAT monitoring system overcomes these problems by permanently measuring the RF parameters such as polarization discrimination, uplink EIRP, C/N, Eb/N0, modulation type, symbol rate, BER, etc. of all operational terminals belonging to the network.

This approach allows detecting and solving problems in a very early phase, even before it will become transparent to the customer and before it will cause significant interference to other services.

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