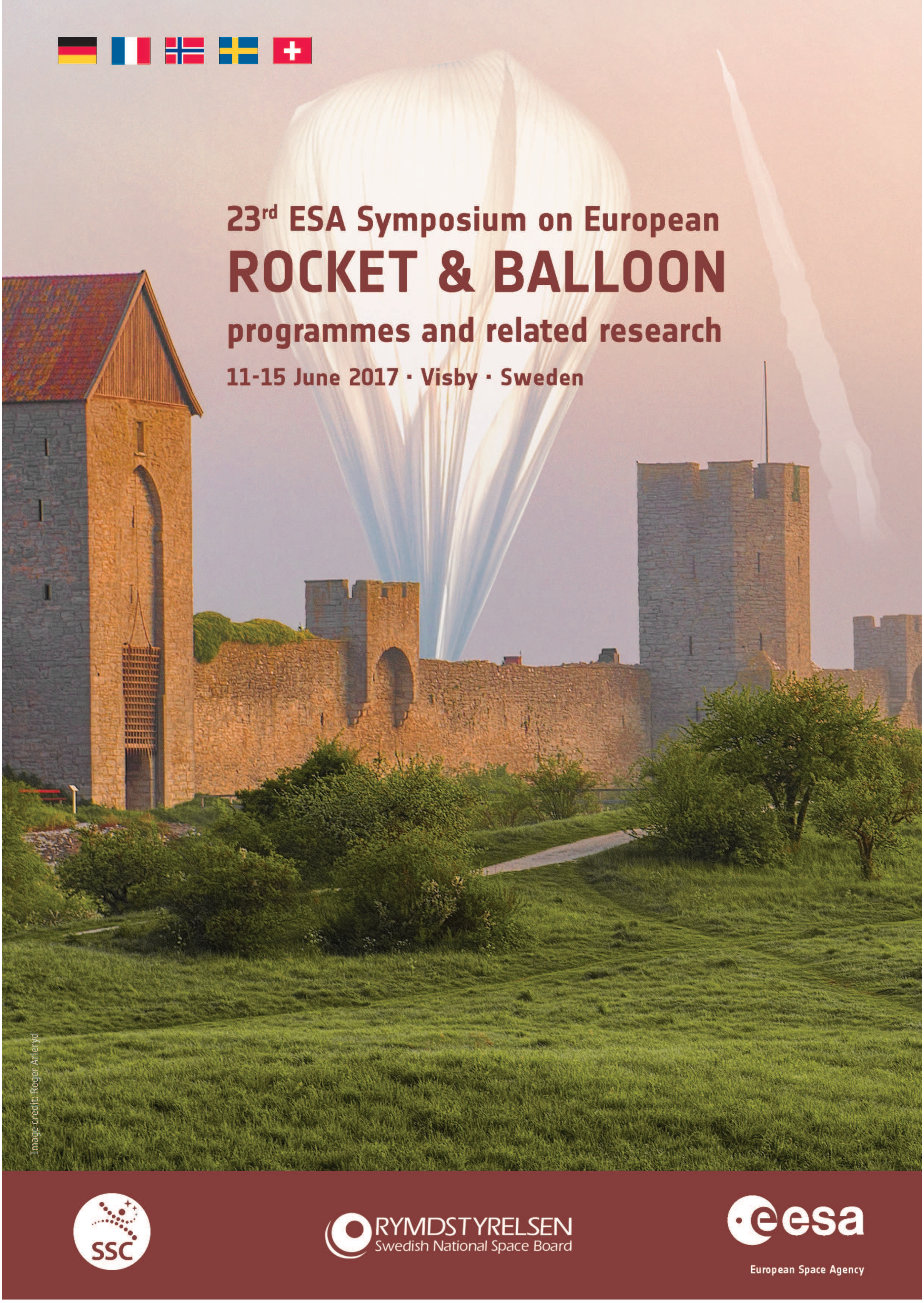
23rd ESA Symposium on European
ROCKET & BALLOON
programmes and related research
11-15 June 2017 · Visby · Sweden
SSC
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Swedish National Space Board
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European Space Agency

Abstracts

23RD ESA SYMPOSIUM ON EUROPEAN ROCKET AND BALLOON PROGRAMMES AND RELATED RESEARCH

11 – 15 June 2017

Visby - Sweden

European Space Agency

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The complete Proceedings will be published in a digital form only, shortly after the symposium. Papers not handed in at the symposium should be sent in pdf to:

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23RD ESA SYMPOSIUM ON
EUROPEAN ROCKET AND BALLOON PROGRAMMES
AND RELATED RESEARCH
VISBY, SWEDEN
11-15 JUNE 2017

PROGRAMME MONDAY 12 JUNE (AM)

OPENING EVENT - ROOM: WISBY

09:00	SYMPOSIUM CHAIR: K. DANNENBERG
09:05	CITY REPRESENTATIVE
09:20	DIRECTOR GENERAL SWEDISH NATIONAL SPACEBOARD: O.NORBERG
09:30	EUROPEAN SPACE AGENCY: M.N. DE PAROLIS
09:40	LOCAL ORGANISING COMMITTEE: S.KEMI

AGENCIES' REPORTS – CHAIR K.DANNENBERG

09:45	SWEDEN – K. DANNENBERG
10:05	GERMANY – O.JOOP
10:25	FRANCE – V. DUBOURG
10:45 – 11:15	COFFEE BREAK
11:15	NORWAY – P. BREKKE
11:35	SWITZERLAND - M. EGLI
11:55	CANADA – S. MONTMIGNY
12:15	JAPAN - T. ABE
12:35	USA – P. EBERSPEAKER
13:00 – 14:15	LUNCH BREAK

MONDAY 12 JUNE AFTERNOON SESSION		PROGRAMME
14:15	PLENARY INVITED LECTURE: [A-171] SHEDDING NEW LIGHT ON THE CRAB AND CYGNUS X-1 WITH POGO+ - M. PEARCE - ROOM: WISBY	
	ASTROPHYSICS, ASTRONOMY & COSMOLOGY Room: Wisby - Chair: M. Pearce	***RANGES FACILITIES*** Room: Lojsta 2 - Chair: S. Kemi
14:45	[A-061] R.M. Millan Highlights from the Barrel Balloon Experiment	[A-036] A. Rathsman Esrange Space Center – Meeting Future Needs for Advanced Space Services
15:00	[A-071] J-P Bernard & PILOT Team In Flight Performances and First Results of the PILOT Experiment	[A-023]P.Hanssen Upgrade of Andoya Space Center's Launch Base at Svalbard – New Opportunities for the Space Science community
15:15	[A-146] E. Caroli Balloon Borne 3D CZT Spectro-imager for Hard X-ray Polarimetry	[A-159]R.Kirchhartz MORABA Activities in Retrospect
15:30	[A-038] T.A.Stein CPT-Scope : Compact particle radiation monitor technology demonstration aboard TEXUS20	[A-087] J. Idivuoma Andoya Space Center Trajectory and Position System (TPS)
15:45	Coffee Break	
	ATMOSPHERIC PHYSICS & CHEMISTRY Room: Lojsta 2 - Chair: J. Gumbel	***TECHNOLOGY & INFRASTRUCTURES FOR SR*** Room: Wisby - Chair: K. Boen
16:15	[A-002] F.J. Lübken Mesopause Jumps: Observations and Explanations	[A-024] S. Nonaka Technical Demonstrations and the Next Steps for Reusable Sounding Rocket
16:30	[A-039] B. Strelnikov Gravity Wave Signatures in Densities of Different Species in MLT as Measured during the WADIS Sounding Rocket Project	[A-015] O.Drescher Cork Based Thermal Protection System for Sounding Rocket Applications – Development and Flight Testing
16:45	[A-053] R. Song Test of a remote Sensing Michelson-interferometer for Temperature Measurements in the Mesosphere on a REXUS Rocket	[A-044] B. Haemmerli In Space with NAMMO's Hybrid Motors: Results and Achievements of the Nucleus Program.
17:00	[A-089] J. Hedin Atomic Oxygen and Temperature in the Lower Thermosphere from the O-States Sounding Rocket Project	[A-055] K.W.Naumann A Modular Sounding Rocket Concept with Green, Safe and Affordable Gelled Propellant Rocket Motors
17:15	[A-132] I. Azeem Super Soaker Sounding Rocket to Study Transport, Chemistry and Energetics of Water in the Middle Atmosphere	[A-026] M. Uitendaal Recent Steps in the T-minus Dart Vehicle Development
17:30	[A-172] J. Stude ROMARA: the ROcket-borne MAss spectrometer for Research in the Atmosphere	[A-157] M. Wittkamp Ethernet for Sounding Rocket
17:45	[A-048] J. Fiedler Variability of Noctilucent Clouds as Observed by the Alomar RMR-Lidar	Withdrawn
18:00	[A-178] H. Asmus Charge Balance of the Night Time D-Region Ionosphere Inferred from In-situ Measurements during the WADIS-2 Sounding Rocket Campaign	
19:00 Ranges Night		

09:00	PLENARY INVITED LECTURE: [A-142] THE ROLE OF SOUNDING ROCKETS IN STUDIES OF MAGNESTOPHERIC CUSP PHYSICS- M. LESSARD - ROOM: WISBY	
	MAGNETOSPHERE & IONOSPHERE Room: Wisby - Chair: J. Moen	***TECHNOLOGY & INFRASTRUCTURES FOR SR*** Room: Lojsta 2 - Chair: M. Viertotak
09:30	[A-009] K. Blix The Grand Challenge Inititiative Cusp Project	[A-148] D.Krause NASA Sounding Rocket Program and Orbital Sciences Corporation - NSROC
09:45	[A-119] C.A.Kletzing Rocket Missions for Cusp Electrodynamics	[A-174] F.Garcia/R.Torres ARION1: The Next European and Reusable Sounding Rocket
10:00	[A-114] N. Ivchenko First Results from the Spider Sounding Rocket	[A-095] P.Caldas-Pinto Stage Concept for a Hovering Thermosphere Probe Vehicle with Green, Safe and Affordable Gelled Propellant Rocket Motors
10:15	[A-113] L. Jahan A Case Study of Sounding Rocket based GPS Signal Reception during Active Auroral Conditions	[A-122] M.Schelim Fields Validation of a Slant Range System at Rio Verde Campaign
10:30	[A-081] G.Giono Langmuir Probes Multi-points Measurements of the Plasma Properties inside an Auroral Electroject Recorded by the Spider Sounding Rocket	[A-050] L.Dawei Well-extensible and Configurable Image Monitor System Onboard Sounding Rocket
10:45	Coffee Break	

	MAGNETOSPHERE & IONOSPHERE Room: Viklau: 3 - Chair: M.Lessard	***UTILISATION OF BALLOONS FOR RESEARCH APP.*** Room: Lojsta 2 - Chair: V. Dubourg	***RANGES FACILITIES*** Room: Wisby - Chair: L. Poromaa
11:15	[A-040] J. Moen Kelvin Helmholtz and Gradient Drift Instabilities in Ionosphere Cusp Flow Channels	[A-020] P. Maier ORISON, a Stratospheric Project	[A-084] K. Nehrman The New Old Process of Rocket Wind Weighing
11:30	[A-018] T. Abe On the Estimation of Ion Drift Velocity from Electrostatic Probe Data Obtained during ICI-4 Campaign	[A-182] – A. Korsfeldt Larsén Albedo Measurement using Photodiodes on a High Altitude Balloon	[A-088] J. Idivuoma Orientation Calculations using 3-Axis Magnetometer
11:45	[A-149] Y.Kyzyurov Features of Sporadic-E Layer below the Turbopause	[A-162] S.Venel CNES Super Pressure Balloons Upgrade for Strateole-2 Campaign	[A-124] W. Jung EUROLAUNCH – A cooperation in change
12:00	[A-082] T.Sergienko BROR – Barium Release Optical and Radio Rocket Experiment	[A-134] E.F.Young Status of NASA's GHAPS Project; Gondola for High-altitude Planetary Science	[A-120] H. Eriksson Esrange Space Center – New Telecommand System
12:15	[A-133] P.A.Bernhardt Results from the Second Charged Aerosol Release Experiment (CARE II) Rocket Experiment	[A-126] C. Lockowandt POGO+ - The Swedish National Transatlantic Balloon Mission	[A-060] H.Oliveira da Mata Artificial Neural Network for Range Flight Safety
12:30	[A-068] C-F. Enell Eiscat Incoherent Scatter Radar Facilities for Ground-based Atmospheric and Solar-terrestrial Science in the Northern Auroral Oval	[A-177] M-P. Zorzano The Packman Radiation and Environmental Instrument for Space Studies	[A-121] K. Larsson Esrange Space Center – New Telemetry Station at Esrange Space Center
12:45	[A-115] X.Zhou Development of a Balloon-borne NIR Camera for Auroral Observations under the Sun		[A-156] M. Abrahamsson Esrange Space Center – Latest Highlights and Future Plans

13:00 – 14:15 Lunch

TUESDAY 13 JUNE AFTERNOON SESSION		**PROGRAMME**
14:15	PLENARY INVITED LECTURE: [A-129] NEW SYNERGIES OF SR AND REMOTE SENSING IN THE UPPER MIDDLE AND LOWER UPPER ATMOSPHERE - J. GUMBEL - ROOM: WISBY	
	ATMOSPHERIC PHYSICS & CHEMISTRY Room: Wisby - Chair: B. Strelnikov	***TECHNOLOGY & INFRASTRUCTURES FOR SR*** Room: Lojsta: 2 - Chair: O.R. Enoksen
14:45	[A-076] R.Latteck Characteristics of Polar Mesosphere Summer Echoes during the Maxidusty Campaign at Andenes, Norway in Summer 2016	[A-154] A.Thurswaldner Making the Case for Sounding Rocket Guidance System
15:00	[A-028] K.Schütze Collection of Stratospheric Aerosols Particles during the BEXUS20 Balloon Campaign by Team COSPA	[A-074] T.Lauritsen Gronas Design and Qualification of a Novel Pyrotechnical Release System for Sounding Rockets
15:15	[A-042] T.Antonsen / O.Havnes Estimates of the Size Distribution of Meteoric Smoke Particles from In Situ Measurements with Dust Impact Probes	[A-097] J-E Ronningen NAMMO Space Products and Activities
15:30	[A-086] T.Staszak A New Rocket-borne Meteor Smoke Particle Detector (MSPD) for D-Region Ionosphere	
15:45	Coffee Break	

16:15

PICO SESSIONS

Room: Wisby - Chair: A. Kinnaird

MAGNESTOSPHERE & IONOSPHERE

[A054]	O.Brekhov	Balloon Gradient Magnetic Measurements and Satellite Magnetic Surveys Synergy

ASTROPHYSICS, ASTRONOMY & COSMOLOGY

[A-145]	G.Roudil	Mechanical Design and Thermo-elastic Analysis of the PILOT Instrument

LIFE & PHYSICAL SCIENCES

[A-047]	F.Meyer	Experimental Findings on Flame Propagation along PMMA Samples in Reduced Gravity on REXUS20 (UB-FIRE)

SPACE-RELATED EDUCATION

[A-066]	St Pieterscollege	Secondary School Students Designing, Testing and Flying Equipment to Study the Quality of µGravity on Drop Tower Tests, Parabolic & Suborbital Flights
[A-107]	M.Kossagk	LOTUS-D – Light Optical Transmission-experiment of University Students
[A-123]	A.L.Duarte	Signon from BEXUS23
[A-065]	St Pieterscollege	Secondary School Students Designing, Testing and Flying Geiger Counter Equipment to Study Atmospheric Gammas over Europe and Svalbard
[A-043]	O.Brekhov	Engineering Satellite Model as a Tool for Satellite Design, its Exploitation and Student Education
[A-169]	L.Klicker	SLED Failure Analysis: How to Fail when you are Destined to Succeed.

UTILISATION OF BALLOONS FOR RESEARCH APPLICATIONS

[A-057]	L.Wang	Command Filtered Back-stepping Integrated Guidance and Control for Hypersonic Glider based on Extended State Observer

UTILISATION OF ROCKETS FOR RESEARCH APPLICATIONS

[A-032]	R.Gardi	MINI-IRENE: Design of a Capsule with Deployable Heat Shield for a Sounding Rocket Flight Experiment
[A-181]	V.Luizzi	Stratospheric balloon trajectory simulations in the Antarctic Polar Vortex for Duster Flights
[A-179]	C.Bian	The Payload Service System of Kunpeng-1B Sounding Rocket

TECHNOLOGY & INFRASTRUCTURES FOR SOUNDING ROCKETS

[A-010]	R.Lu	Deisgn and Flight Results of a Non-polluting Cold-separation Mechanism for TY-3F Sounding Rocket
[A-027]	H.Otlhof	Recent Steps in the T-Minus Dart Motor Development
[A-139]	S.Haas	REXUS19 – LIME (Link Made Early) – Investigation of an Attitude-dependent Satellite Communication Scheme
[A-140]	A.Zaghdane	UB-Space on REXUS21: Test Data Acquisition for Relative Navigation with a Camera System for a 360 Degree Round View from a Sounding Rocket

TECHNOLOGY & INFRASTRUCTURES FOR BALLOONS

[A-022]	X.Deng	Properties of a Gas-compression based Pressure Control System for Stratospheric Airship
[A-166]	J-B Béhar	Coriolis Mass-Flowmeter for Aerostatic Gas Amount Determination in Zero Pressure Stratospheric Balloons
[A-058]	G.Xu	Research on High Power Stacked Boost Converters for the Power Supply of Stratospheric Airship
[A-180]	T-T. Liu	The Influence of the Solar Cells on Thermal Characteristics of Stratospheric Airship

09:00	PLENARY INVITED LECTURE: [A-175] HUMAN CELLS IN MICROGRAVITY – D. GRIMM - ROOM: WISBY	
	ASTROPHYSICS, ASTRONOMY & COSMOLOGY Room: Lojsta: 2 - Chair: J-P. Bernard	**LIFE & PHYSICAL SCIENCES** Room: Wisby - Chair: M. Egli
09:30	[A-170] Design and 2016 Flight Performance of POGO+ - A Balloon-borne Hard X-ray Polarimeter	[A-011] M.Knie First Insights on the Influence of Altered Gravity on the Gene Expression in Daphnia Magna – A Sounding Rocket Experiment (TEXUS52)
09:45	[A-128] Y. Longval PILOT Optics and its in-flight performance	[A-003] S.L.Wuest Electrophysiological Measurements during a Sounding Rocket Flight, Results from the CEMIOS Experiment on REXUS20
10:00	[A-077] L. Dorman Forward to Automatic Forecasting of Radiation Hazards from Solar Cosmic Rays for Experiments on Long-lived Baloons, for Aircrafts and Spacecrafts	[A-051] T.J.Corydon Alterations of the Cytoskeleton in Human Cells in Space Proved by Life-Cell Imaging
10:15	[A-105] B.Mot Characterisation and Performances of the PILOT Instrument	[A-001] S.Kopp Thyroid Cancer Cells in Space – Results of the TEXUS53 Mission
10:30	Withdrawn	[A-090] M.Krüger Life-cell Imaging of F-actin Changes Induced by 6 Min of Microgravity on a TEXUS Sounding Rocket Flight
10:45	Coffee Break	

	ATMOSPHERIC PHYSICS & CHEMISTRY Room: Lojsta: 2 - Chair: F-J. Lübken	**LIFE & PHYSICAL SCIENCES** Room: Viklau - Chair: A. Verga	**TECHNOLOGY & INFRASTRUCTURES FOR BALLOONS** Room: Wisby - Chair:M. Abrahamsson
11:15	[A-091] T.Kuhn Comparison of In-situ Balloon-borne and Lidar Measurement of Cirrus Clouds	[A-080] B. Pröbster FOKUS II – A Vacuum Compatible Dual Frequency Comb System	[A-130] E.Carlsson Sjöberg BOOSTER – BallOOn for Science and Technology from Esrange
11:30	[A-085] T.Antonsen Simultaneous In Situ and Remote Observations of Dust in the Polar Summer Mesosphere : an Overview of the Maxidusty Campaign	[A-037] M.Podgorski DREAM – Drilling Experiment for Asteroid Mining	[A-143] J.Hruby Development of Ultra-sensitive Portable 3D Magnetometer based on Diamond NV-centers for OSCAR (BEXUS23)
11:45	[A-144] V.Wolf Properties of Ice Particles in Arctic Cirrus from Balloon-borne in-situ Measurements at Different Meteorological Conditions	[A-158] A.Schütte/G.Florin Size Matters – MAXUS9 Sounding Rocket Mission	[A-019] S.Rückerl TDP-3 Vanguard : Verification of a New Communication System for Cubesats on BEXUS 22
12:00	[A-059] J. Söder Measuring Wave Generated Stratospheric Turbulence with a Lightweight Balloon-borne Instrument	[A-125] Y.Houltz XRMON-SOL Microgravity Experiment Module on MASER13	[A-079] K.Garg Design, Verification and Validation of a Simulation Tool for High-Altitude
12:15	[A-108] E.J.Young Prospects for Improved Infrasound Detection from Balloon-borne Platforms	[A-152] G.Florin MASER13 Sounding Rocket Mission – Worth Waiting for	[A-014] J. Peeters Thermal Analysis of Components for Stratospheric Experiments using Finite Element Model Updating of the BEXUS20: HACORD Mission
12:30	[A-165] H.Oelhaf 25 Years of Atmospheric Science with MIPAS-B	[A-106] H.Oltmann Flumias and Perwaves : Two Exciting New Experiment Modules	[A-006] Q.Liu An Experimental Investigation into the Thermal Performance of Sphere Balloon
12:45		[A-160] A.Vaerneus Roots in Space – The BIM-3 Microgravity Experiment Module	[A-004] J.Cai Analysis of Transient Surface Temperature and Aerodynamic Heating for Space Exploration Balloon
13:00 – 14:15 Lunch			
14:15 Excursions			

Thursday 14 June Morning Session — Programme

Time	Session	
09:00	Plenary Invited Lecture: [A-031] 10 Years of the German-Swedish REXUS/BEXUS Student Programme – A. Kinnaird/M. Becker - Room: Wisby	
	Space-Related Education 1 Room: Wisby - Chair: K. Dannenberg	***Utilisation of Rockets for Research Applications*** Room: Lojsta 2 - Chair: R. Kirchhartz
09:30	[A-030] K.Schüttauf The STERN Project – Hands on Rockets Science for University Student	[A-041] M.Yang The Recent Development of China Sounding Rocket Space Exploration Activities and the Internal Cooperation
09:45	[A-173] Jean Oswald PERSEUS	[A-045] K.Sjölander O-STATES & SPIDER/LEEWAVES, a new Era of National Sounding Rockets from Esrange Begins
10:00	[A-100] C.Stausland Fly a Rocket ! A Norwegian-ESA Educational Programme – PILOT Cycle Report and Conclusions	[A-046] T.Gansmoe Development of New Payload Module for 4D Measurements
10:15	[A-109] S.G.Bilen Developing Student Leadership in Space Systems Engineering via the G-chaser Student Rocket	[A-131] M.Siedorf MIRKA2-RX – An Educational Precursor Mission for a Re-entry based Cubesat Mission
10:30	[A-056] B.Jensen STARBUST – A New, Unique Student Project in Maritime Surveillance from Space	[A-049] B.Tester Experimental Results from the Testing of the Prototype Inflatable Conical Antenna – REXUS Deployment on REXUS Flight RX19
10:45	Coffee Break	

Time			
	Utilisation of Balloons for Research App. Room: Viklau - Chair: V. Dubourg	***Space-Related Education*** Room: Wisby - Chair: M. Becker	***Utilisation of Rockets for Research App.*** Room: Lojsta 2 - Chair: W.Jung
11:15	[A-005] Z.Qu High Altitude Balloon Launched Micro Glider: Design, Manufacturing and Flight Test	[A-064] D.Nilsson SALACIA – A Study of Martian Brines with REXUS21	[A-136] A.Schütte TEXUS – Latest Developments and New Perspectives
11:30	[A-073] S.Wlach DLR ELAHA – Current Development State of an Unconventional Stratospheric UAV	[A-127] J.Gorski Freon Decay Experiment On Board of BEXUS21 Flight	[A-033] P.Vernillo MINI-IRENE: The First European Flight Experiment of a Deployable Heat Shield
11:45	[A-078] M.Laabs Results from the Inflatable, Textile and Rigidisable Antenna (INTEX) Experiment on the BEXUS21 Mission	[A-093] D.Geeroms / S.Vuurstaek Using a Habduino for Telemetry in Arctic Atmospheres as a Hands-on Space Education Project for Secondary School Students	[A-135] K.Roed Miniaturised Sub-payload for Multi-point In-situ Measurements on the G-chaser Student Rocket
12:00	[A-101] S.Nagels BEXUS23 OSCAR: Solar Cell I-V Monitoring System for Space Environments	[A-112] A.Buzdugan WOLF REXUS Experiment	[A-083] G.Giono Detailed Photocurrent Characterisation for Meteor Smoke Particle Detectors Onboard the PMWE Sounding Rocket
12:15	[A-147] J.Lukacevic Findings of the PREDATOR Experiment – BEXUS23	[A-067] E. de Schrijver Bifrost Parabolic Flight: A New Recurrent Hands-on Space Education Programme for Secondary School Students	[A-092] J.Breitinger Launch Campaign of the Hybrid Sounding Rocket HEROS
12:30	[A-151] G.Florin Balloons and Sounding Rockets – Platforms for Drop Tests	[A-052] L.Frezza Assessment of the VHF Omnidirectional Range (VOR) Performance in the Stratosphere: STRATONAV on BEXUS22	[A-098] K.Szafran Pneumatic Reentry Vehicle – Evaluation of Transport System for Return to Earth
12:45	[A-062] T.A.Mis Balloon Micro Lifeform-and-Meteorite Assembler (BULMA) Experiment for BEXUS22 Launch Campaign	[A-094] F.Hertel Trajectory Analysis of the Hybrid Sounding Rocket HEROS	[A-070] G.Lindahl Recent and Future Norwegian Sounding Rocket Projects conducted by Andoya Space Center

13:00 – 14:15 Lunch

THURSDAY 14 JUNE AFTERNOON SESSION		PROGRAMME
14:15	PLENARY INVITED LECTURE: [A-153] IN SITU X-RAY STUDIES OF METAL ALLOY SOLIDIFICATION IN MICROGRAVITY CONDITIONS – THE XRMON PROJECT- H. NGUYEN-THI - ROOM: WISBY	
	LIFE & PHYSICAL SCIENCES Room: Wisby - Chair: A. Verga	***TECHNOLOGY & INFRASTRUCTURES FOR SR*** Room: Lojsta 2 - Chair: D.Krause
14:45	[A-025] L.Maywald REXUS22 GRAB: Assessment of the Adhesive Properties of Gecko-inspired Materials under Space-like Conditions	[A-008] A.Kolbe Design of Hybrid Lightweight Fins for Sounding Rockets
15:00	[A-150] A.Vaerneus The XRMON-DIFF2 Diffusion Experiment on MAXUS9 Mission	[A-102] M.Friedrich On the Calibration of Plasma Probes on the Maxidusty Mesospheric Rocket Payloads
15:15	[A-021] A.Cartasi U-PHOS Experiment: Thermal Response of a Large Diameter Pulsating Heat Pipe On Board REXUS22 Rocket	[A-111] A.Jegatheesan Low Cost Navigational Data Recording Payload for SERA Sounding Rocket
15:30	[A-069] T.Trittel Thermally Induced Material Flow in a Two-dimensional Liquid Crystal Film	Withdrawn
15:45	Coffee Break	
	LIFE & PHYSICAL SCIENCES Room: Wisby - Chair: M. Egli	***TECHNOLOGY & INFRASTRUCTURES FOR SR*** Room: Lojsta 2 - Chair: K.Blix
16:15	[A-029] L. Sturz Multiple Equiaxed Dendrite Interaction Investigated on MASER13	[A-116] F.Wolf / M.Engert RACOS – A Cold Gas Rate Control System On Board of REXUS 22
16:30	[A-034] J.Grosse Lessons Learned from the First Flight of an Atom Interferometer Payload on a VSB-30 Sounding Rocket Payload	[A-104] E.Zakutin Overview of the Dipole Inflatable Antenna Experiment (DIANE) within the REXUS21 Mission
16:45	[A-117] D.Becker Sounding Rocket Mission MAIUS-1: Creating the First Bose-Einstein Condensate in Space	[A-110] B.Klein / L.Stamat Horizon Acquisition for Attitude Determination using Image Processing Algorithms – Results of PATHOS on REXUS20
17:00	[A-035] G.Zimmermann Columnar-to-equiaxed Transition in the Transparent Alloy System NPG-DC for Different Gravity Levels – The Experiment “TRACE-3”	Withdrawn
20:00 Gala Dinner		

SYMPOSIUM OVERVIEW – SESSION BY SESSION

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Agencies' Reports

Monday 12 June, morning session – part 1

Chair: K. Dannenberg

[A-168]

SWEDISH SPACE ACTIVITIES – GENERAL OVERVIEW WITH A FOCUS ON BALLOONS AND ROCKETS

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Swedish space research involves many fields of space science, such as astronomy, space physics, astrobiology, atmospheric research, life and physical sciences in microgravity and Earth observation. A major part of Swedish space research activities is supported by the Swedish National Space Board (SNSB), within its national programmes for space research and Earth observation. Most projects utilise flights offered by ESA programmes and/or data provided by ESA satellites and other space missions. Several national projects deal with the utilisation of balloons and rockets, launched from the Esrange Space Center in Northern Sweden. SNSB has also established a new national initiative dealing with small innovative satellites, aiming at launching a new science satellite every three years. The first satellite, MATS, is currently under development, and a phase A study of the next candidate mission is ongoing.

In autumn 2016, the Esrange Space Center celebrated its 50 years' anniversary, with a major milestone of more than 1000 launches of rockets and balloons. Esrange and its utilisation is emphasised in the strategy of SNSB as one of the focus areas within the national space programme. These activities are of high relevance as they provide unique opportunities of combining basic science with instrument and platform development as well as close cooperation between universities and industrial partners. In order to meet the needs of the Swedish space community and to promote scientific utilisation of Esrange, SNSB is carrying out a dedicated national programme for rocket and balloon experiments with regular calls for proposals.

During the recent years, several successful balloon and rocket launches have been performed within the national balloon and rocket programme. One of the major projects is the balloon experiment PoGO+ that was launched from Esrange in July 2016 and recovered in Northern Canada after six days of successful flight. The PoGO+ experiment deals with the studies of polarisation of gamma-rays from extreme astrophysical objects, such as Crab Nebula. The first analysis of the data has shown very promising results. Another balloon project, In-situ IWC, involves multiple launches of smaller balloons to perform in-situ studies of ice particles in clouds.

Three national rockets were successfully launched in 2015/2016. Two consecutive launches of the O-STATES experiment took place in October 2015 to study oxygen species in the thermosphere, using the same payload that was quickly refurbished during less than two weeks. Another sounding rocket, launched in February 2016, carried two experiments, SPIDER and LEEWAVES, with 14 free-flying units to study the turbulence in the auroral electrojet and gravitational waves.

Sweden takes an active part in the student rocket and balloon programme REXUS/BEXUS. The programme is a joint undertaking of DLR and SNSB, in cooperation with ESA, and a call for proposals is being issued every year, offering an opportunity to carry out student experiments on real rockets and balloons. Two REXUS rockets and two BEXUS balloons are being launched from Esrange every year and more than 1000 European students have participated in the programme since its start in 2007.

Besides national activities, Sweden contributes to many ESA programmes. The ELIPS and E3P programmes involve considerable Swedish participation, and Swedish activities are mainly focused on MASER and MAXUS sounding rockets for microgravity research as well as drop tests from high altitude balloons.

[A-013]

SOUNDING ROCKET AND BALLOON RESEARCH ACTIVITIES WITHIN THE GERMAN SPACE PROGRAMME 2015 - 2017

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Sounding (suborbital) rockets and stratospheric balloons currently play a major role in the following research disciplines of the German space programme: Space Science, Life and Physical Sciences under Microgravity, Space Technology development, and Education. In its role as space administration DLR manages these activities and promotes the related experiments by grants and contracts. Involved research entities are mainly German universities, the Max-Planck Society, the Helmholtz Association, the Fraunhofer Association, and the Leibniz Community.

In its role as a research establishment DLR also executes flight projects. The DLR Mobile Rocket Base (MORABA) provides launch services for rockets and balloons. The DLR Institute of Materials Physics in Space develops and conducts own microgravity experiments in the frame of the MAPHEUS research rocket missions. The institutes in Bremen and Braunschweig contribute to the MAIUS programme. Further DLR institutes participate in flights with rocket technology experiments or support the STERN programme.

The National Report highlights the German research activities in the timeframe 2015 – 2017. In the Space Science discipline the research focus was the middle atmosphere of the Earth using stratospheric balloons, lidars, and DLR FALCON flights, e.g. during the LITOS concerted campaign. Further, in-situ measurements of atmospheric parameters up to 140 km are conducted by sounding rocket campaigns (e.g. PMWE) from the Andøya launch site in Norway. The scientific coordination of these missions is performed by the Leibniz-Institute of Atmospheric Physics at the University of Rostock (IAP) in Kuehlungsborn. 3-dimensional measurements are targeted for the near future by releasing three daughter payloads from a single rocket. Biological, physical, and chemical phenomena under microgravity conditions were studied by German scientists using ESA's MAXUS 9 as well as national TEXUS, MAPHEUS, and MAIUS missions on parabolic trajectories.

Within the German-Swedish REXUS/BEXUS student programme more sounding rocket and balloon missions have been performed successfully. A wide range of scientific and technological experiments such as atmospheric physics, satellite communication, and test of space equipment was addressed by the selected student teams. Other German educational programmes like STERN, D-CanSat, or StratoSAT have been continued or initiated during the last two years.

[A-096]

FRENCH BALLOON ACTIVITIES 2015 – 2018

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The French Centre National d'Etudes Spatiales (CNES) goes on supporting a significant balloon program and infrastructure, for scientific and technological purposes.

Designed to be mobile, the CNES balloon systems and operation means can be deployed and operated worldwide, at several latitudes. The extended range of vehicles and payload gondola support provided by CNES allow addressing several kinds of missions such as astronomy, atmospheric physics and chemistry, stratospheric and tropospheric meteorology.

The main undertaking of the past 7 years was to deeply renovate the CNES balloons command and control systems and flight operation processes to cumply with more stringent Safety constraints and with growing performance and reliability requirements. This is done for big zero pressure balloons (ZPB), and in progress for the other lines of products.

Since 2014, 15 successful scientific flights of ZPB have been carried out from Timmins (Canada) and Kiruna (Sweden), and 3 flights should take place from Australia in spring 2017.

In the field of long duration balloons, CNES decided, in june 2016, the development of the STRATEOLE 2 project, for the study of the low stratosphere in equatorial regions. Based on the use of fleets of small super pressure balloons (SPB) flying up to 3 months each, the program consists in two launch periods in late 2020 and 2023. The related infrastructure will be available no later than end of 2018, paving the way to a new capacity for long duration flights in general.

A synthesis of the launch campaigns of the past two years will be presented: Regarding ZPB flights, a focus will be made on the results of the KASA 2016 flights at Esrange, Kiruna, as well as on the preliminary results of the AUSTRAL 2017 campaign in Alice Springs; the status about the FIREBALL UV payload will be given.

An outlook of the new systems currently developed at CNES will be given, in particular the SPB system for Strateole 2, and the perspectives for new developments and collaborations will be presented.

[A-063]

NORWEGIAN NATIONAL REPORT – ARCTIC SPACE RESEARCH

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Norway has long traditions as a space nation, much due to our northern latitude. Our space science activities are concentrated into relatively few areas. This concentration is necessary due to limited resources, both in funding and personnel. The main scientific activities are within Solar-terrestrial physics and cosmology.

The first field has been a priority since before the space age and is still the major priority. The usage of the ground infrastructure in Northern Norway and on Svalbard is essential in studying the middle and upper atmosphere and the interaction with the Sun. This includes the utilization of sounding rockets, both small and large, and ground based installations like radars, lidars and other optical instrumentation. The planned use of Svalbard as a launch site for large stratospheric balloons may allow the cosmology community access to our northern infrastructure. The solar physics community is also heavily involved in the HINODE and IRIS missions and Norway is supporting downlink of data via the Svalbard Station for these missions .

The sounding rocket program is in close collaboration with many countries like Germany, USA, Canada and Japan. Two scientific sounding rocket programs are currently being pursued: The ICI series (from Svalbard) and MaxiDusty (from Andøya).

A significant improvement of today's polar and ionospheric research infrastructure in Northern Norway and Svalbard has recently been put on the ESFRI roadmap for European research infrastructure through the SIOS and EISCAT 3D initiatives. The SuperDarn radar at Svalbard is now operating to study space weather. The Norwegian Mapping Authorities new VLBI facilities at Svalbard is under construction and will be operating in 2018. Furthermore, the new fiber optical cable from Ny Ålesund to Longyearbyen was finished in 2015.

Norway is also participating in ESA´s Space Situational Awareness program with a strong focus on the space weather elements. In particular to utilize, and further develop the arctic space infrastructure. A national space weather center has been established in Tromsø to serve the user needs in Norway.

A small satellite with a space weather instrument onboard will be launched into a polar orbit in 2017.

[A-176]

SOUNDING ROCKET AND BALLOON ACTIVITIES AND RELATED RESEARCH IN SWITZERLAND 2015–2017

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Preferred session: National report

In Switzerland balloons, sounding rockets and the height altitude research stations of Jungfraujoch and Gornergrat remained attractive as research platform for studies in microgravity, astrophysics, astronomy and atmospheric science. Because the two research stations in the Alps are offering alternative access to the upper atmosphere, particularly for long-duration studies (up to several years), the places have been visited frequently by scholars to find answers to their unique scientific questions. The data gathered there however cannot replace measurements taken by balloons or sounding rockets and therefore Swiss researchers participate on such missions often.
One example of a balloon mission conducted by a Swiss consortium during the indicated time period is the "Integrated Vehicle Health Management System Demonstrator" or also called "Smartfish". Aim of the study was to test the system and to take readings from the atmosphere by an automated flying vehicle while descending from high altitude. A balloon was used to deliver the "Smartfish" to the target altitude. During the several drops conducted at ESRANGE, the system worked perfectly and thus proved its usability.
Besides enabling research access to the upper atmosphere, balloon and sounding rockets do also represent an excellent opportunity for students to get involved in space experiment and through this to acquire new skills. The "CEMIOS" project that was proposed and conducted by students from the Lucerne University of Applied Sciences and Arts is a good example of how Swiss students can profit from educational programs like REXUS/BEXUS. Goal of the "CEMIOS" project was to determine potential changes of the ion flux through the membrane of living cells under microgravity conditions. A compact electrophysiological experiment, applying a patch-clamp technique was built to comply with the space requirements and to fit into the sounding rocket. The launch took place in spring 2016 and although the cells did not survive the flight, the students learned a lot by participating.
The national report provides a short overview on Swiss projects within the framework of sounding rocket and balloon activities and related research performed between 2015 and 2017. A few studies are presented in more detail as examples of the current work Swiss research groups are engaged.

[A-016]

CAPABILITY DEMONSTRATION PROGRAM IN CANADA

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Canada has a strong national strategic interest in space. Space will be used as a way to drive a broader economic growth and leveraged for the benefits of Canadians. Canada's future in space relies on innovation, advancement of science and technology, and future generation of highly educated and skilled space scientists and engineers. A strong Canadian space capability demonstration program is needed for maintaining Canada's leading edge in space and developing new capabilities for the future. The Canadian Space Agency (CSA), in response to the needs expressed by Canadian space industry, academia, and the government, and to better prepare Canada to capture future mission and commercial opportunities, is in the process of developing a capability demonstration program, which includes both pre-space demonstration and space demonstration. Demonstration in space onboard a satellite or a space platform (e.g. ISS) is the most desirable method to demonstrate new technology, scientific approach or capability. However, there are only a limited number of opportunities for space demonstration flights and the associated cost is usually high. Suborbital platforms, such as balloons and rockets, remain popular for the academia and industry engaging in space science and engineering to test their hardware and approaches as they provide near-space environments with low cost and easy access.

This paper discusses the needs for a capability demonstration program and its overall objectives, and provides greater details on demonstration activities using suborbital platforms, including on-going stratospheric balloon flights, parabolic flights, and possible rocket flights in the future for Canada.

[A-155]

OVERVIEW OF JAPANESE SOUNDING ROCKET ACTIVITY IN 2015-2016

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Japanese sounding rockets have been launched to achive various objectives such as thermospheric, ionospheric and magnetospheric physics, microgravity experiment, demonstration of various instrument and technique, and advanced engineering experiments. In the years of 2015-2016, three rockets were launched from Uchinoura Space Center which exists in the south part of Japan. In this presentation, we will introduce recent activities of sounding rocket in Japan

In September 2015, we conducted "S-520-30" sounding rocket experiment which aims at clarifying the nucleation process of oxide-based cosmic dusts. A certain amount of oxides was evaporated under the micro-gravity environment during a ballistic flight of the rocket, and the experiment team directly measured the generation and growing process of oxide particles that were condensing after the evaporation. For the measurement, two kinds of instruments were used; 1) a dual-wavelength interferometer, 2) an on-site measurement instrument of floating dust infrared spectra. More detailed analysis has been performed by the team.

In January 2016, sounding rocket "S-310-44" equipped with a suite of five science instruments was launched to elucidate a mechanism of the ionospheric electron heating in the Sq current focus. Data from the Fast Langmuir Probe (FLP) onboard the rocket suggest that the electron temperature increased by about 200 K with respect to the background in the altitude range from 100 to 110 km in the current focus. It is significant that the electron energy distribution observed in the Sq current focus unlikely seems to obey *Maxwellian* distribution and sometimes exhibits a possible existence of *non-Maxwellian* component in the high electron temperature region. Electron current from the fixed bias probe and power spectrum from HF plasma wave receiver indicate that the amplitude in the frequency range of several hundred Hz was enhanced at the E region altitude. Thus, multiple unusual properties of plasma were remarkably observed in the vicinity of the Sq current focus. We now recognize that this region is very unique and can be considered as attractive region comparable to the ionospheric cusp.

In January 15, 2017, SS-520-4 sounding rocket was launched from the Uchinoura Space Center. Through this launch, we carried out research and development of launch vehicles and very small satellites, and also conducted the launch demonstration of TRICOM-1, its onboard nanosat that weighs about 3 kilograms. The launch was a part of Japanese government's program for development of launch vehicles and satellites in public-private partnerships. Unfortunately, ground teams could not receive telemetry from the launch vehicle, and the call was made to abort the second stage ignition.

We will continue the current level of sounding rocket activity in the next years. In addition to the sounding rocket activity report, recent activities on scientific balloon experiment and the future sounding rocket program will also be introduced.

[A-141]

NATIONAL REPORT ON THE NASA BALLOON AND SOUNDING ROCKET PROGRAMS

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The U. S. National Aeronautics and Space Administration (NASA) Balloon and Sounding Rocket Programs conduct a total of 30 to 40 missions per year in support of the NASA scientific community and other users.

The NASA Balloon Program supported numerous scientific and technology development missions since its last report. The program conducted flights from the United States, Antarctica, and New Zealand utilizing Zero Pressure Balloons (ZPB) and Super Pressure Balloons (SPB). Of particular note are the launch of three heavy-lift 532 thousand cubic meter SPB Ultra Long Duration test flight missions launched from Wanaka, New Zealand that included cutting edge science missions of opportunity; science missions incorporating the 2-Axis Wallops Arc Second Pointer (WASP) systems; and the second launch of the NASA/JPL Low Density Supersonic Decelerator Mars decelerator test vehicle launched from Hawaii. NASA Safety has incorporated enhanced capabilities that have provided increased insight needed for real time flight management decision making. Also presented is the NASA cutting-edge science that is achieved using NASA balloons.

The NASA Sounding Rockets Program supports the science community by integrating their experiments into the sounding rocket payloads, and providing both the rocket vehicle and launch operations services. Activities since June 2015 have included two flights from Andoya Rocket Range, more than ten flights from White Sands Missile Range, ten flights from Wallops Flight Facility, and five flights from Poker Flat Research Range. The overall success rate for the program during this period was 85 %.

Activities included the refinement of designs associated with small rocket propelled subpayloads to enable payload "swarms" to enhance scientific return, assessment of new recovery techniques to enable recovery for missions with large impact ranges, and numerous investigations into new economical, high flying vehicles. Other accomplishments included upgraded manufacturing capabilities, upgrades to numerous systems and components such as inertial measurement units, telemetry components, solar sensors, and flight termination systems as well as upgrades to Poker Flat launch range in Alaska. The Peregrine rocket motor development project experienced some technical setbacks that have prompted a redesign effort.

Astrophysics, Astronomy & Cosmology 1

Monday 12 June, Afternoon session – part 1

Chair: M. Pearce

Plenary Invited Lecture

[A-171]

SHEDDING NEW LIGHT ON THE CRAB AND CYGNUS X-1 WITH POGO+

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Polarimetry is an established probe of celestial sources across a broad range of wavelengths, excluding X-rays and gamma-rays. Advances in this energy band are instead currently driven by spectroscopy, imaging and timing studies. This is a significant shortcoming, since many X-ray sources are dominated by non-thermal emission with radiation transferred in highly asymmetric systems. A measurement of the linear polarisation of the emitted radiation therefore constitutes a key observable and powerful diagnostic for sources which cannot be spatially resolved. Until satellite observatories are realised, intial data-sets can be obtained from instruments flown on-board stratospheric ballooning platforms. PoGO+ is a balloon-borne hard X-ray polarimeter operating in the 20 - ~150 keV energy band. Polarisation properties of incident X-rays are measured in a segmented array of plastic scintillators surrounded by a BGO anticoincidence system and a polyethylene neutron shield to mitigate background. The design is developed from the PoGOLite Pathfinder mission which made a preliminary measurement of the polarisation of hard X-rays from the Crab in 2013. These measurements are the first in the hard X-ray band using a purpose built polarimeter which had been characterised with both polarised and unpolarised beams prior to flight. The PoGO+ mission was launched from the Esrange Space Center in July 2016 with the Crab and Cygnus X-1 as the primary observation targets. The outcome of the 2016 flight will be reviewed and first results from observations presented.

[A-061]

HIGHLIGHTS FROM THE BARREL BALLOON EXPERIMENT

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BARREL is a balloon investigation designed to study the loss of electrons from Earth's radiation belts. Discovered in 1958, the radiation belts are filled with energetic electrons traveling at speeds near the speed of light. This region of near-Earth space is known to be highly variable, and many questions remain about the mechanisms responsible for rapidly energizing particles to relativistic energies there. Atmospheric loss of relativistic electrons plays an important role in radiation belt dynamics. The importance of understanding the radiation belts continues to grow as society becomes increasingly dependent on spacecraft which travel through this region for navigation, weather forecasting, and more.

BARREL campaigns were conducted in Antarctica in 2013 and 2014, and Sweden in 2015 and 2016, during which a total of 55 balloon payloads were launched. Each balloon carried a NaI scintillator to measure the bremsstrahlung X-rays produced by precipitating relativistic electrons as they collide with neutrals in Earth's atmosphere. The balloons made measurements in conjunction with NASA's Van Allen Probes, several cubesat missions, and a wide range of ground-based instrumentation including riometers, magnetometers, auroral imagers, and EISCAT. This presentation will provide an overview of the BARREL mission and highlight some recent science results.

[A-071]

IN FLIGHT PERFORMANCES AND FIRST RESULTS OF THE PILOT EXPERIMENT

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Measuring precisely the faint polarization of the Far-Infrared and sub-millimetre sky is one of the next observational challenges of modern astronomy and cosmology. These observations can reveal the structure of the magnetic field and the role it plays in shaping the filamentary structure of the interstellar medium and in the poorly understood process of star formation. They can also reveal in a unique way some of the physical properties of the dust particles, the emission of which dominates in this wavelength range. Finally, this polarized emission is a screen to cosmology of the cosmic microwave background that needs to be understood and removed precisely before any firm conclusions about the primordial universe can be established.

The PILOT balloon-borne experiment is dedicated to measuring the linear polarization of the faint interstellar diffuse dust emission in the far-Infrared in our Galaxy and nearby galaxies. The first successful flight of the experiment took place from Timmins, Canada in September 2015. A second flight will have been carried out from Alice Springs, Australia before the date of the Symposium.

I will present the in-flight performances of the experiment as observed during the flights and will present preliminary scientific results obtained so far.

[A-146]

BALLOON BORNE 3D CZT SPECTRO-IMAGER FOR HARD X-RAY POLARIMETRY

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The measurement of the polarization status of the high-energy emission from cosmic sources is a key observational parameter, to understand fully the radiation production mechanism and its geometry. Therefore, future instrumentation operating in this energy range should be optimized also for this type of observation. We present and discuss the concept of a small high-performance imaging spectrometer designed for polarimetry between 100 and 600 keV suitable for a stratospheric balloon-borne payload. This instrument would be able to perform accurate and reliable polarimetry measurements of different cosmic ray sources types, simultaneously with fine spectroscopic measurements and imaging.

The payload, based on a detector with intrinsic 3D spatial resolution (2 mm), relies on CZT spectrometer sensors in a highly segmented configuration. The sensitive detection area will be of few hundreds of cm2, enough to guarantee the sensitivity to detected 1/10 of the Crab flux during a typical balloon observation time (104 s). The detector will be coupled with a simple Coded Mask optimized for imaging up to 100 keV, which will be used to monitor the source and the neighbour field during each observation.

After an overview of various suitable detector configurations based on recent development results and possible improvements currently under study, we describe the baseline design of the proposed payload and the required payload resources. Finally, we present Monte Carlo evaluations of the achievable minimum detectable polarisation for the adopted payload configuration, and the expected sensitivity for some strong sources (e.g. Crab).

[A-038]

CPT-SCOPE: COMPACT PARTICLE RADIATION MONITOR TECHNOLOGY DEMONSTRATION ABOARD BEXUS 20

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In October 2015, the Cosmic Particle Telescope (CPT-SCOPE) instrument was flight-tested from Kiruna, Sweden, aboard the BEXUS 20 balloon. The technology demonstrator was developed by Norwegian and German students with the objective to detect energetic particles in the mixed radiation field of the tropo- and stratosphere at Northern latitudes. Based on a stack of silicon detectors and absorbers two redundant instruments were built combining radiation-hard integrated circuits with COTS components. The detector geometry was varied to expand the detectable range of particles.

Housekeeping data such as position, temperatures and pressure were recorded. The science data was obtained from individual triggers of four detectors used in each instrument. The Pfotzer-Maximum was recovered from altitude-dependent count rate data.

This paper outlines the results with additional efforts to recover coincidence triggers. The obtained science data is compared to instrument simulations using FLUKA. The CPT-SCOPE data and instrument design is reviewed. The measurements of other BEXUS payloads capable of detecting atmospheric particle precipitation is evaluated with focus on the Belgium BEXUS 20 HACORD instrument. We further elaborate lessons learnt, and present the outcome of CPT-SCOPE outreach and educational activities. The paper concludes with a description of follow-up developments targeting a miniature, CubeSat-ready radiation monitor for space and terrestrial mixed-field applications.

RANGE FACILITIES 1

MONDAY 12 JUNE, AFTERNOON SESSION – PART 1

CHAIR: S.KEMI

[A-036]

ESRANGE SPACE CENTER – MEETING PRESENT AND FUTURE NEEDS FOR ADVANCED SCIENCE SERVICES

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Esrange Space Center has been used by the international scientific community, space agencies and commercial customers for the past 50 years. Over 550 sounding rockets for microgravity and atmospheric research and over 520 high altitude balloons for astronomy, atmospheric research and drop tests have been launched since Esrange was founded.

The requirements and driving forces have of cause changed during the past five decades, today there is still a demand for sounding rockets and balloons as important tools for science but there is also a need for extended service capabilities. Esrange Space Center is presently undergoing a major upgrade and expansion; project "New Esrange", to meet both the present and future needs for advanced science services. The project includes both modernization and upgrading of existing infrastructure as well as investments in new rocket launchers, technology and research platforms.

The aim is to be able to offer cost effective launch services and more frequent launch opportunities for sounding rockets and balloons, improved possibilities to perform coordinated measurements from ground based instrumentation, balloons, sounding rockets and satellites as well as new capabilities for affordable and easy access to space. The new services will include full scale testing of reusable space vehicles, technology tests for space exploration by means of re-entry and landing tests, robotic rover tests in a Moon and Martian like environment and SmallSat Express, a European launch capability for small satellites.

This presentation will present the plans for "New Esrange" in more detail as well as current project status.

[A-023]

UPGRADE OF ANDØYAS SPACE CENTER'S LAUNCH BASE AT SVALBARD – NEW OPPORTUNITIES FOR THE SPACE SCIENCE COMMUNITY

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Andøya Space Center (ASC) is in the process of upgrading the installations at SvalRak - ASC's launch base for sounding rockets in Ny-Ålesund at Svalbard. The upgrades include new wind measurement system, new intercom and communication system and a new launcher with a protective shelter to protect the rocket and payload to weather and environment until shortly before launch. ASC has now several mobile telemetry stations in its inventory. Thus, future campaigns in Ny-Ålesund will have complete redundant telemetry systems. The upgrade also means that now it will be possible to implement parallel rocket campaigns at Andøya and Svalbard, as well as simultaneous launches from both bases.

The most significant upgrade is however a new launcher. Two modern launchers with protecting shelters in Ny-Ålesund provides new opportunities for the scientific community. The paper will focus on what type of rockets that can be launched from Svalbard and in particularly the opportunities, the upgrades can offer the space research community.

[A-159]

MORABA ACTIVITIES IN RETROSPECT

Dr. Rainer Kirchhartz, Wolfgang Jung, Marcus Hörschgen-Eggers

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The Mobile Rocket Base (MORABA) of the German Aerospace Center DLR celebrated its fiftieth anniversary on 1 January 2017. During this time MORABA has carried out more than 500 rocket and 200 balloon launches in the service of science from launch sites all over the world. In addition to being a service provider for sounding rocket and balloon launches, MORABA has become a well-recognized developer of unique and customized flight systems. Examples include the SHEFEX 1 and 2 hypersonic research missions.

MORABA has been cooperating with global partners for decades and considers the collaborative efforst as a key element to successful missions. As one of the longest standing collaborations, DCTA/IAE of Brazil has together with MORABA, developed and continues to develop various launch vehicles such as the VS-30/Imp. Orion and the VSB-30. Since 2003, MORABA and SSC Esrange Space Center have extended their cooperation of the common 50 year history to the EuroLaunch framework for microgravity and student missions. Great benefits for the sounding rocket community have been provided through the cooperation with Andoya Space Center specifically in the field of flight testing of new vehicle combinations. MORABA also works closely together with the Australian Defense, Science and Technology Group (DSTG) as part of the hypersonic research program HIFiRE.

Within the framework of the presentation, the highlights and trailblazer missions will be presented since the last ESA PAC Symposium:

- O-States 1 and 2: First launch of the S31/Imp. Orion vehicle (Oct 2015)
- Combined Flight Ticket on MASER 13: One contact point for the customer (Dec 2015)
- Spider: Use of extreme spherically blunted nose for apogee adjustment (Feb 2016)
- Imp. Malemute Qualification 1 and 2: Military surplus motor converted into a new sounding rocket (Jul 2016)
- ROTEX-T: First flight of a Terrier/Imp. Orion vehicle with a hypersonic research experiment from ESC, alternative recovery concept (Jul 2016)
- STERN Program: Students achieve an amateur record with their own build hybrid rocket (Nov 2016)
- MAIUS-1: First Bose-Einstein condensate generated in space (Jan 2017) and payload diameter increased to 500mm
- REXUS / BEXUS Extension: More than 1000 students trained since the beginning of the program
- ROBEX: Supporting robotic exploration

An outlook will be provided on upcoming missions as well as on the planned expansion of the rocket family with military surplus motors as well as the medium-term development of the microsatellite launcher VLM-1 together with DCTA/IAE.

[A-087]

ANDØYA SPACE CENTER TRAJECTORY AND POSITION SYSTEM (TPS)

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The Trajectory and Position System (TPS) is one of the most critical software systems during campaigns at Andøy Space Center. The main functionality of the system is to gather the payload position information from all available input sources, weight the data and present actual position, velocity vector and instantaneous impact point at real-time. Furthermore, the TPS system handles all logging of position data necessary to perform a postflight trajectory analysis, in addition to providing guiding functionality to tracking antennas.

Several input data clients are fully integrated at existing system, as for example radar, several GPS position formats and ASC telemetry antenna controllers. Since the system is fully developed at ASC, thus owning the code-base, we also have the possibility to integrate new types of clients whenever needed.

An integrated part of the TPS is the ASC developed slantrange measuring system for telemetry antennas, the Time Interval Counter (TIC). The TIC-system provides us together with the pointing angles of the telemetry antenna with the rocket position information even without radar or GPS tracking.

An overview of the Andøya Space Center TPS system will be presented. The TIC-system is covered in more detail, the basic principles are described and the accuracy of position measurements using telemetry antannas equipped with the TIC-system is compared to radar and GPS measurements.

ATMOSPHERIC PHYSICS AND CHEMISTRY 1

MONDAY 12 JUNE, AFTERNOON SESSION – PART 2

CHAIR: J. GUMBEL

[A-002]

MESOPAUSE JUMPS: OBSERVATIONS AND EXPLANATION

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Recent high resolution temperature measurements by resonance lidar at Davis (69◦S) occasionally showed a sudden mesopause altitude increase by ∼5 km and an associated mesopause temperature decrease by ∼10 K. We present further observations which are closely related to this 'mesopause jump', namely the increase of mean height of polar mesospheric summer echoes (PMSE) observed by a VHF radar, very strong westward winds in the upper mesosphere measured by an MF radar, and relatively large eastward winds in the stratosphere taken from reanalysis. We compare to similar observations in the Northern Hemisphere, namely at ALOMAR (69◦N) where such mesopause jumps have never been observed. We present a detailed explanation of mesopause jumps. They occur only when stratospheric winds are moderately eastward and mesospheric winds are very large (westward). Under these conditions, gravity waves with comparatively large eastward phase speeds can pass the stratosphere and propagate to the lower thermosphere because their vertical wavelengths in the mesosphere are rather large which implies reduced dynamical stability. When finally breaking in the lower thermo-sphere, these waves drive an enhanced residual circulation that causes a cold and high-altitude mesopause. The conditions for a mesopause jump occur only in the Southern Hemisphere (SH) and are associated with the late breakdown of the polar vortex. Mesopause jumps are primarily, but not only, observed prior and close to solstice. We also show that during the onset of PMSE in the SH, stratospheric zonal winds are still eastward (up to 30 m/s), and that the onset is not closely related to the transition of the stratospheric circulation.

[A-039]

GRAVITY WAVE SIGNATURES IN DENSITIES OF DIFFERENT SPECIES IN MLT AS MEASURED DURING THE WADIS SOUNDING ROCKET PROJECT

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The WADIS project (Wave propagation and dissipation in the middle atmosphere: energy budget and distribution of trace constituents) aimed at studying waves, their dissipation, and effects on trace constituents. The project comprised two sounding rocket campaigns conducted at the Andøya Space Center (69 °N, 16 °E). One sounding rocket was launched in summer 2013 and the other in winter 2015.

It is well known that the densities of neutral air and heavy plasma constituents in the Mesosphere/Lower Thermosphere (MLT) region are modulated by Gravity Waves (GW). The densities as well as temperatures are therefore used to derive GW-parameters which are important for understanding the dynamics of the atmosphere.

In-situ measurements conducted in the frame of the WADIS project delivered high resolution altitude-profiles of neutral air temperature and density, turbulence energy dissipation rates, as well as plasma and atomic oxygen densities. Analysis of fluctuations of these species revealed signatures of gravity waves and their dissipation.

In the paper we show some results of analysis of GW-signatures in different atmospheric constituents in the MLT.

[A-053]

TEST OF A REMOTE SENSING MICHELSON-INTERFEROMETER FOR TEMPERATURE MEASUREMENTS IN THE MESOSPHERE ON A REXUS ROCKET

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The experiment AtmoHIT, the Atmospheric Heterodyne Interferometer Test, is a precursor mission with the goal to verify a small satellite remote sensing instrument under space conditions. The satellite instrument is developed to measure temperatures in the Mesosphere/ Lower- Thermosphere. Temperature measurements allow the characterization of gravity waves, which have an increasing importance in the modelling of the climate system representing one of the larger uncertainties in this field. The instrument consists of a highly miniaturized and rigid Spatial Heterodyne Spectrometer (SHS), which measures the oxygen atmospheric band emission in the Mesosphere. The instrument resolves individual rotational lines whose intensities follow a Boltzmann law allowing for the derivation of temperature from the relative structure of these lines. This instrument is characterized by its high throughput at a small form factor to perform scientific remote sensing measurements with a CubeSat. The AtmoHIT experiment is part of the Rocket Experiment for University Students campaign (REXUS 22), realised under a bilateral Agency Agreement between the German Aerospace Centre (DLR) and the Swedish National Space Board (SNSB). This contribution focuses on the developed technologies, laboratory measurements and rocket campaign results.

[A-089]

ATOMIC OXYGEN AND TEMPERATURE IN THE LOWER THERMO-SPHERE FROM THE O-STATES SOUNDING ROCKET PROJECT

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In October 2015 the O-STATES payload was launched twice from Esrange Space Center (67.9°N, 21.1°E) in northern Sweden, first into moderately disturbed and then into calm geomagnetic conditions. The basic idea of O-STATES ("Oxygen Species and Thermospheric Airglow in The Earth´s Sky") is that comprehensive information on the composition, specifically atomic oxygen in the ground state $O(^3P)$ and first excited state $O(^1D)$, and temperature of the lower thermosphere can be obtained from a limited set of optical measurements. Starting point for the analysis are daytime measurements of the $O_2(b^1\Sigma_g^+ - X^3\Sigma_g^-)$ Atmospheric Band system in the spectral region 755-780 nm and the $O(^1D\text{-}^3P)$ Red Line at 630 nm. In the daytime lower thermosphere, $O(^1D)$ is produced by O_2 photolysis and the excited $O_2(b)$ state is mainly produced by energy transfer from $O(^1D)$ to the $O_2(X)$ ground state. In addition to O_2 photolysis, both electron impact on $O(^3P)$ and dissociative recombination of O_2^+ are major sources of $O(^1D)$ in the thermosphere.

Laboratory studies at SRI International have shown that $O_2(b)$ production in vibrational level v=1 dominates. While $O_2(b, v=0)$ is essentially unquenched, $O_2(b, v=1)$ is subject to collisional quenching that is dominated by O at altitudes above 160 km. Hence, the ratio of the Atmospheric Band emission from $O_2(b, v=1)$ and $O_2(b, v=0)$ is a measure of the O density at sufficiently high altitudes. In addition, the spectral shape of the O_2 Atmospheric Band is temperature dependent and spectrally resolved measurements of the Atmospheric Bands thus provide a measure of atmospheric temperature. This O_2 Atmospheric Band analysis has been suggested as a new technique for thermospheric remote sensing under the name Global Oxygen and Temperature (GOAT) Mapping. With O-STATES we want to characterize the GOAT technique by in-situ analysis of the O_2 Atmospheric Band airglow and the underlying excitation mechanisms. By performing this dayglow analysis from a rocket payload, detailed local altitude profiles of the relevant emissions and interacting species can be obtained.

The payload carried a comprehensive instrument set for neutral atmospheric and ionospheric composition measurements. This includes a newly developed and actively cooled package of nine photometers adoptable to optical measurements from the ultraviolet to the infrared. The O-STATES project will be described and results from the campaign will be presented.

[A-132]

SUPER SOAKER SOUNDING ROCKET TO STUDY TRANSPORT, CHEMISTRY, AND ENERGETICS OF WATER IN THE MIDDLE ATMOSPHERE

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Water deposition in the Mesosphere and Lower Thermosphere (MLT) from space traffic can lead to significant variations in the composition and dynamics of the region. *Stevens et al.*, 2005 and *Kelley et al.*, 2010, for example, showed that the fast global-scale plume transport from NASA's Space Shuttle launches can lead to the formation of PMCs. This is an important finding because PMCs have been implicated as possible indicators of long-term climate change [*e.g. Thomas and Olivero*, 2001 and references therein]. There has been a great deal of focus on the fate of the water in the MLT region. The water plume phenomenon raises a number of important questions about lower thermospheric and mesospheric processes, ranging from dynamics and chemistry to PMC formation and climatology. The Super Soaker rocket mission, funded by the NASA Heliophysics Technology and Instrument Development for Science (H-TIDes) program, seeks to investigate the time-dependent neutral chemistry and transport of water in the MLT and to determine the resultant impact on the local temperature and ice cloud formation. Super Soaker is tentatively scheduled for launch in April 2018 from the Poker Flat Rocket Range (PFRR), Alaska. The mission is designed to release a plume of water vapor from a rocket payload and observe how the atmosphere responds both during and after the release. The rocket experiment will be supported on the ground by lidar observations of temperature and PMCs, temperature maps using the Advanced Mesosphere Temperature Mapper (AMTM), ground-based wind observations using TMA releases, PFISR observations of electron density, and data from the NASA AIM and TIMED satellites. In this paper we review the Super Soaker rocket mission and describe initial numerical modeling results to provide a semi-quantitative view of the response of chemistry and energetic to the water plume deposition in the lower thermosphere. One important result of this modeling work is that water vapor released near 90 km altitude actively cools the atmosphere, which enables the local formation of ice clouds. We will also present the design of the water payload section which will release a large volume of water at a specific time in the mission. We will discuss novel design solutions and innovations implemented to ensure dispersion of the water at release point.

[A-172]

ROMARA: THE ROCKET-BORNE MASS SPECTROMETER FOR RESEARCH IN THE ATMOSPHERE

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ROMARA is a quadrupole mass spectrometer to detect charged particles or cluster ions at altitudes above 50 km with a mass per charge ratio of up to 2000 amu/q.

The aim is to study polar mesospheric winter echoes (PMWE) during the upcoming PMWE sounding rocket campaign of the Leibniz Institute of Atmospheric Physics. In contrary to polar mesospheric summer echoes (PMSE), where ice particles are the cause of such echoes, the temperature of the mesosphere in winter is too high for the formation of ice particles. It is therefore assumed that the winter-echoes are caused by electrically charged meteoric smoke particles (MSP) instead. These particles are thought to originate from the re-condensation of ablated meteoric material. Thus particles of iron, magnesium and silicon and their compounds should exist in the corresponding altitude.

E.g., Rapp et al. (2012) showed that groups of these elements are likely to form e.g. $(FeOH)_4$, $(MgOH)_4$, $(FeSiO_3)_3$ and $(Mg_2SiO_4)_4$ with a preference to the hydroxides over the silicates. Robertsen et al. (2012) measured MSPs in October with the condition of a "warm" mesosphere to avoid ice particles. Significant densities of particles in the range of 500 amu/q to 2000 amu/q were measured, and even larger masses of up to 20000 amu/q were present. However, the used Faraday cup type instrument had a low mass resolution (M/dM) of around 1 and thus it was not possible to determine compositions more precisely. In mass analyzing the particles with higher mass resolution it should be possible to better constrain the composition of eventually present particle precursors and relate them to meteor smoke particles under PMWE conditions.

The ROMARA instrument represents a modified and improved version of the ROMAS (ROcketborneMAss Spectrometer) instrument, originally developed and deployed by the MPIK (Max-Planck-Institute for Nuclear Physics-Heidelberg) group of F. Arnold. ROMARA can be tuned for ion detection with relatively high mass resolution. However as mass increases, the sensitivity of the instrument decreases. Therefore, for massive charged MSPs only a relatively low mass resolution of only 10 - 50 can be achieved. The here presented instrument consists of a compact quadrupole filter (rod-length: 116 mm; rod-radius: 2.3 mm), a channel electron multiplier for ion detection, a liquid-neon cooled cryo pump, a conically shaped sampling electrode, an ejectable cap, and electronics. ROMARA is mounted on the top of a sounding rocket. The cap seals the instrument at lower altitudes and contains an ion source for testing instrument operation during the ascent. The cap is ejected at around 50 km altitude to allow the entry of ions and electrically charged MSPs through an inlet orifice, located at the tip of the sampling cone. Neutral gas molecules are frozen out by the liquid neon cryo pump. The ROMARA instrument measures mass spectra of negative or positively charged ions and MSPs.

[A-048]

VARIABILITY OF NOCTILUCENT CLOUDS AS OBSERVED BY THE ALOMAR RMR-LIDAR

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The highest clouds in the Earth atmosphere are located around 83 km altitude. They were first documented in 1885 and are called noctilucent clouds (NLC) because of the impressive bluish-white displays they form against the dark night sky. NLC are the visible manifestation of ice particles, persistently present in the polar summer mesopause region, which are subject to the variability of the ambient atmosphere. Ice formation and growth at these high altitudes is very sensitive to temperature and water vapor content which are both hardly to measure directly with high accuracy. Thus NLC are used as tracers for short-term variations and are thought to document long-term atmospheric changes as well. The altitude of NLC is the longest lasting data set of measurements from the neutral upper atmosphere, first determined by optical triangulation in 1890. Since the early days of such investigations, the accuracy and data basis of NLC altitude measurements has been substantially improved by means of lidar remote sensing.

The ALOMAR RMR-lidar, located at 69°N, started operation in 1994 and covers by now 2990 hours NLC signatures during 6230 measurement hours within 23 seasons. This largest NLC data set acquired by lidar contains variabilities of basic cloud parameters like occurrence, altitude and brightness on time scales ranging from minutes to years. Results from our lidar single shot acqisition system (LISA) show small scale waves having observed periods of only 20 seconds. For structures between 5 and 30 minutes a new approach of identification and analysis was developed, based on template matching. Such structures are linked to gravitiy waves and appear only locally in NLC. On semidiurnal and diurnal scales, NLC show distinct and persistent variations which are attributed to atmospheric tides. On multi-year time scales, trend investigations of NLC parameters show only small changes within the last two decades. We will summarize our recent findings and highlight their importance for understanding the variability in the mesopause region.

[A-178]

CHARGE BALANCE OF THE NIGHT TIME D-REGION IONOSPHERE INFERRED FROM IN-SITU MEASUREMENTS DURING THE WADIS-2 SOUNDING ROCKET CAMPAIGN

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Rocket-borne measurements and model studies show that at northern latitudes the nighttime ionosphere above about 80 km contains predominantly negatively charged Meteoric Smoke Particles (MSPs). Models suggest that most of the charge is on the smallest particles and only a small part of bigger particles is charged. The data available to date also suggest that the density of the negative ions diminishes downwards of 80 km due to e.g. recombination reactions with the atomic oxygen. It is believed that atomic oxygen in the nighttime D-region ionosphere also controls the charging process of MSPs.

In this paper we show a simple D-region charging model constrained by common volume in-situ density measurements of all the ionospheric dusty plasma species and of atomic oxygen. The model is applied to the nighttime data obtained during the WADIS-2 sounding rocket campaign conducted in March 2015 at the Andøya Space Center (69°N, 16°E). The rocket soundings yielded high resolution common volume measurements of densities of all dusty plasma species including neutrals, electrons, positive ions, and charged MSPs, as well as the density of atomic oxygen.

We show the measurement and modeling results and discuss possible implications on the winter D-region ionosphere.

TECHNOLOGY AND INFRASTRUCTURES FOR SOUNDING ROCKETS 1

MONDAY 12 JUNE, AFTERNOON SESSION – PART 2

CHAIR: K. BOEN

[A-024]

TECHNICAL DEMONSTRATIONS AND THE NEXT STEP FOR REUSABLE SOUNDING ROCKET

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In order to make the access to space for scientific researches much easier and make the opportunities of the rocket launches much frequent, a fully reusable sounding rocket is proposed in ISAS/JAXA. The mission definition of the proposed reusable sounding rocket are 1) To achieve 100km in altitude and returns to the launch site, 2) The 100kg payload to be carried, 3) Flight frequency is higher than 10 times per a year, 4) The minimum flight interval is one day, and 5) Operational flight cost should be an order of magnitude less than the existing ISAS sounding rocket. Reusable sounding rocket is different from the present expendable rockets in 1) repeated operations, 2) returning flight / re-ignition of engine / vertical landing, that is, 3) fault tolerant / health management. Some key technologies related to these characteristics of reusable system have been verified to design an operative reusable sounding rocket in phase-A. Technologies velifications respect to the reusable vehicle, 1) reusable engine development and repeated operations, 2) reusable insulation development for cryogenic tank, 3) aerodynamic design and model flight demonstration for returning flight, 4) cryogenic liquid propellant management demonstration, 5) landing gear development, and 6) health management system construction, have been successfully conducted from 2010 to 2016.

After these technical demonstrations, we are proceeding with a study for system level velifications by a flight demonstrator from 2016 as the next step for the development of reusable sounding rocket. In this plan, a small test vehicle will be establish for repeated flight demonstrations. Objectives of the demonstration are 1) system architecture study for repeated flight operation such as quick turnaround operation and fault tolerant design method, 2) life controlled and frequently repeated use of cryogenic propulsion system and its flight demonstrations, 3) study for the advanced returning flight method of vertical landers and its flight demonstrations, and 4) demonstration of advanced technology for future RLVs such as more composite on board, in flight fuel management, GH2/GOX auxiliary propulsion, health management, long-life & high performance engine. These system level studies by a reusable flight demonstrator will be conducted for next three years.

In this paper, ISAS/JAXA activities for development reusable launch vehicle, that is, technical demonstrations for reusable sounding rocket and a plan and present status of flight demonstrations by reusable rocket demonstrator, are summarised and reported.

[A-015]

CORK BASED THERMAL PROTECTION SYSTEM FOR SOUNDING ROCKET APPLICATIONS – DEVELOPMENT AND FLIGHT TESTING

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The application of aerospace thermal protection systems (TPS) is not limited to orbital flight and re-entry vehicles. Although less critical in terms of the thermal load's magnitude, it is also an essential part of sounding rocket primary structures.

For a large variety of launch vehicles, DLR's Mobile Rocket Base (MORABA) uses thermal protection systems on primary structures such as fin, nose cone, conical adapter and heat shield assemblies. Hereby, an ablative, epoxy based, two component thermoset coating has been the material of choice over several decades. Using relatively simple manufacturing methods, it can be sprayed onto almost any geometry. However, its noxious fumes released during the spraying process, its limited shelf life, its extensive storage requirements and above all, its residues polluting adjacent payload components during the ablation phase, are the key drivers for the development of a new thermal protection system using a special cork material.

This paper presents the development and manufacturing process as well as flight testing and post-flight analyses for different cork protected structural components flown on recent scientific missions (e.g. MAIUS1, MAPHEUS6, etc.). Results are discussed and a future outlook is given.

[A-044]

IN SPACE WITH NAMMO'S HYBRID MOTORS: RESULTS AND ACHIEVEMENTS OF THE NUCLEUS PROGRAM.

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Under an ESA FLPP contract, Nammo is developing a hybrid motor, the Unitary Motor (UM), to demonstrate the feasibility of using hybrid propulsion for sounding rocket and nano-launcher applications. The UM is a 30kN thrust class motor using as propellant high concentration hydrogen peroxide and HTPB-rubber. The UM is the building block of the propulsion stages of the North Star Family, a Norwegian initiative of sounding rockets and Nano-launchers.

As a first step, Nammo will launch from Andøya Space Center (ASC) the Nucleus: a sounding rocket based on a single UM propulsion system. The goals of this launch are to test the propulsion system in a representative environment and to demonstrate the applicability of the technology. The project has finalized the design activities in December 2016 and manufacturing started in early 2017. The launch is then scheduled for late summer 2017.

Among the activities that have been performed for the Nucleus development, the principal one has been to design, develop and manufacture the airframe structures and the flight weight version of the rocket fluid system (H2O2 tank, pressurizer cylinder, valves,…). In particular, multi-way valves have been designed and manufactured, with a functioning up to 400 bars, and friction steer welding has been selected and qualified as manufacturing process for the oxidizer tank. Trajectory analysis, safety assessment and payload design and manufacturing have been performed in collaboration with ASC. The design and manufacturing activities culminate in the static testing of the full Nucleus propulsion system in spring 2017. The static test set-up is made as representative as possible of the final flying system, while keeping all the safety infrastructure and procedure already in place in Nammo's test center.

In order to support and fulfill all the ground activities around the rocket, a dedicated Ground Support Equipment has also been developed. All the control and safety equipments needed to operate safely the rocket and avoid any hazard are included, along with the filling systems. The launch pad had also to be specially equipped and adapted in order to address the specificities of the hybrid technology.

This paper provides an overview of the Nucleus project achievements and results. Descriptions of all the subsystems are as well provided, along with the expected performances for the upcoming launch. Finally an outlook on the current status of the project, the remaining challenges to be achieved before the launch and the follow-up of the project are presented.

[A-055]

A MODULAR SOUNDING ROCKET CONCEPT WITH GREEN, SAFE AND AFFORDABLE GELLED PROPELLANT ROCKET MOTORS

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This paper presents the design concept of a 2-stage sounding rocket using green, safe and affordable gelled propellant rocket motors (GRM). This includes mass and performance data as well as trajectory calculations.

The status of the GRM technology and programme as of 2015 describes Ref. 1. In the frame of potential applications of GRM, Ref. 1 outlines some features of a sounding rocket stage with GRM. Tests with long operation times up to 85 seconds verified the wide usability of a cost-efficient combustion chamber design. And low cost in production, transport, handling, safety and launch procedures is essential for the cost-driven sounding rocket business. Another property of our GRM technology is environmentally friendly combustion products. Our gelled rocket propellant (GRP) itself is as green as propellants can be that are storable at ambient pressure and temperature.

The sounding rocket concept with GRM is highly modular. Both stages are identical with respect to the general design, the GRP tank and the high-pressure gas tank with ancillary components for the propellant feeding system. In the version with multi-motor blocks the 6 GRM for the first stage and the 3 GRM for the second stage are identical as well with a nominal thrust of 30 kN each. The filament wound structures for tanks and skirts are also designed for easy production procedures. The diameter and interfaces are set to fit into the launch tower at ESRANGE, whereas rail launch is also possible. The GRP is chosen for a high specific impulse that is better than that of aluminized solid propellants. The controllability of the GRM is used either to stabilize the axis of the rocket assembly in pitch and yaw direction in order to reduce cross-wind dispersion or, if a system for guidance and navigation is on board, to control the thrust vector. Calculations of the trajectory show that with the standard payload section (400 kg) of the VSB-30 rocket assembly the required altitude of the apogee can be achieved. In addition, the potential to eliminate cross-wind dispersion allows launches at cross-wind velocities and gradients that would interdict launches of sounding rockets without correction.

1 K. W. Naumann, P. Caldas-Pinto, J. Ramsel, H. Niedermaier, S. Scheutzow, A. Thumann, " Rockets with Green Gelled Propellants – a Promising Technology for Sounding Rockets", 22nd ESA Symposium on Eur. Rocket and Ballon Programmes, Tromsö, N, 8.-12.6.2015

[A-026]

RECENT STEPS IN THE T-MINUS DART VEHICLE DEVELOPMENT

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The T-Minus DART rocket system is specially designed for scientific research in the middle and upper atmosphere as successor of the unavailable Viper and Super Loki rockets previously used. The higher projected altitude performance of the DART compared to its predecessors, in combination with robust and durable active payloads, enables a completely new way of performing research.

In May 2016, a new test flight of the T-Minus DART, TF-02, was carried out. The test flight was performed at ASK 't Harde in The Netherlands. Building on conclusions drawn from previous tests, the test vehicle was launched from the T-Minus Mobile Launch Tower, equipped with a helical Viper II rail that was borrowed from DLR MORABA (Mobile Rocket Base). The test vehicle was designed as a shape-representative of the production model. A miniaturized deployable payload was implemented for analysis and reconstruction of the flight. The payload contained an IMU that measured 9 time-stamped parameters: acceleration, rotation rate and magnetic field over the three vehicle axes. Additionally, a GPS beacon, radio transmitter and 16 GB of non-volatile on-board storage were implemented. The payload was deployed using an innovative non-pyrotechnic deployment system.

The aim of this test flight was to validate several technologies:

- Active spin stabilisation: a defined spin-rate was induced by the helical Viper launch rail. Mechanical compatibility between the rail and the vehicle was validated;
- Flight dynamics: improved vehicle stability during flight and the absence of pitch-roll coupling due to active spin stabilization was validated. Simulation software was validated for low altitude flights;
- Separation dynamics: data on dynamics during the separation of booster and dart was collected by means of an on-board Inertial Measurement Unit (IMU).
- Aerodynamics: the aerodynamic characteristics of the vehicle were determined based on flight data, enabling the validation of the aerodynamic model, and comparison between CFD data, wind tunnel data and flight data;
- Electronics and payload ejection mechanism: the full prototype of the flight electronics of the dart, including the new payload ejection system was tested;
- Operations: the operations of TV-02, made identical for the future production of the T-Minus DART, were validated.

The flight was completely successful, and valuable data was gathered.

[A-157]

ETHERNET FOR SOUNDING ROCKETS

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The standard interface for experiment computers for forwarding low to medium data rates to the Service Module on a Sounding Rocket payload is still the asynchronous UART protocol on a RS422 physical layer. This interface is well known, easy to implement and debug. However, it is limited in speed and signal integrity when it comes to high bit rates. Further, the UART protocol cannot be routed without additional layers of communication, since it was designed to serve as a point to point protocol.

A common interface to overcome these problems is Ethernet together with the TCP/IP family of protocols. Some experimenters are already using this stack in their laboratory.

This paper presents a communication architecture which provides Ethernet onboard a Sounding Rocket to provide the flexibility of this standard system to the experiments. The architecture is based on a pair of gateways to adapt to the existing TM/TC systems without modifying them. The system requires transparent octet-streams on both TM and TC. It replaces the Ethernet frame and forwarding data of the IP communication layer.

Due to the nature of IP based communication, the messages become routable and Firewalls might be used at the Gateways on both ends to protect the TM/TC connections from unwanted packets.

Within the paper we describe the details of the architecture, the design of the two Gateways and benchmarks of the actual implementation.

[A-007]

RESEARCH ON SOUNDING ROCKET RECYCLING DESIGN METHOD

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Sounding rockets fly in high altitudes between balloons and satellites and they are the only means of applying in-situ detection of near space from 40 to 300 kilometers in height. There is a growing need for spatial exploration in the near space so more exploration activities are required in the future. This allows the task of recycling part of the payload on the arrow to be a counted as part of the schedule, which will ultimately lead to a higher efficiency of the researches of its launch. At the same time, during the thirteenth five-year plan of micro-gravity science experiments on the recovery system, higher and stricter requirements are proposed.

According to needs of sounding rocket program, the first part presents the modeling of recovery parachute and airbag, subsequently the mechanical analysis and thermal analysis of parachutes, and structural design of airbag on water landing and inflation. In the inflation impact dynamics analysis of parachutes, multiple operation conditions are analyzed and compared, in order to obtain structural parameters meeting the requirement of safety factor while as light as possible. The result provides the basis for structural optimization. Next, simple engineering calculation and simulation approaches are employed to analyze the aerodynamic heating for the parachute, thus predicting the change of skin temperature on the parachute canopy. For the airbag design, inflation and water landing dynamic analysis of folded airbag is conducted to obtain the minimum parameters needed in the severest impact loading condition. Following the result, airbag inflation methods are analyzed and compared.

Points of innovation on the research of the design of aerospace recovery devices is listed as the following:

1.Dynamic characteristics of fluid-structure interaction (FSI) for the inflation of the flexible structure of the canopy fabrics are analyzed by numerical methods, to acquire response results of canopy structure under inflation impact loads. It helps to discuss the relation between the structure’s capability to bear the maximum inflation impact load and sensitive structural parameters. Results will serve as the basis for design optimization.

2.Aerodynamic heating effect is analyzed using simple engineering methods. To compare with the calculation result by hand, two convective heat transfer models in Nastran/Thermal are employed and compared in the simulation.

3.The simulation of folded airbag inflation is conducted in the inverse reasoning method by taking account of the water landing process and the requirement for airbag parameters. Methods of airbag inflation are also compared.

Keywords: recovery parachute, airbag, inflation impact load, structural design

MAGNESTOSPHERE AND IONOSPHERE 1

TUESDAY 13 JUNE, MORNING SESSION – PART 1

CHAIR: J.MOEN

Plenary Invited Lecture

[A-142]

THE ROLE OF SOUNDING ROCKETS IN STUDIES OF MAGNETOSPHERIC CUSP PHYSICS

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The magnetospheric cusp is a relatively small high-latitude region where solar wind energy can, at times, have direct access to Earth's ionosphere and upper atmosphere. In spite of the small size of this region, the complex and intense activity that is typical of the cusp makes it one of the most important "high traffic" areas on Earth, in terms of magnetosphere-ionosphere-thermosphere coupling. Indeed, the cusp is well know as a source of intense auroral displays, ion outflow, thermospheric heating and other processes. These processes are thought to result from various drivers including dayside reconnection, high-latitude reconnection, Traveling Convection Vortices, etc. The spatial scales of these processes make them ideal for rocket-based studies. In this presentation, an overview of cusp physics will be presented as well as results of recent rocket launches.

[A-009]

THE GRAND CHALLENGE INITIATIVE CUSP PROJECT

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The Grand Challenge Initiative (GCI) is a large-scale international collaboration effort targeting advancement in specific, fundamental issues in space and earth science. The GCI concept was conceived and developed over the past two years by the Andoya Space Center (ASC) and the University of Oslo. Their work has culminated in the first GCI project - "GCI Cusp" - to determine the multi-scale physics of heating and charged particle precipitation in the ionosphere specific to the geomagnetic cusp region.

"With 6 NASA sounding rocket missions now manifested for the trilateral (USA, Norway and Japan) "Grand Challenge Initiative – CUSP project", the GCI launch campaign in December 2018 and January 2019 will be a historic event. Consisting of 3 Black Brant XII's, 2 Black Brant X's, 1 Terrier Improved Malemute (G-CHASER student rocket), a SS-520 from ISAS/JAXA and 1 S30/Improved Malemute ICI-5 from Norway, this collaboration will be one for the books on sounding rocketry in terms of the amount of major scientific rockets in one launch campaign, the complexity in telemetry and the complexity in launch criteria for the two simultaneously used launch sites at Andøya, Norway and Ny-Ålesund, Svalbard." The statement comes from Dr. J. Daniel Moses, NASA SRPS, SMD, NASA Hq

The GCI Cusp Project is designed to advance the common understanding of cusp region space physics through coordinated experimental and theoretical research using ground based instruments, modelling, sounding rocket investigations, and satellite based instruments. International student participation through space plasma model development and a dedicated student rocket is an essential aspect of the GCI concept. Strategic use of public outreach, particularly via the tools of social media, is also a vital component of the GCI Cusp Project.

The core of the GCI Cusp Project is a series of sounding rocket missions independently conceived and developed through the respective space exploration agencies of the US, Norway and Japan. The rockets will be launched in conjunction with observations of the cusp from an aggregate of state-of-the-art ground-based scientific instrumentation, including incoherent and coherent backscatter radars, all-sky cameras, meridian scanning photometers, magnetometers, and other instruments, which will operate continuously throughout the launch window.

The main GCI Cusp observational activities will be conducted in the high northern latitude region surrounding the Svalbard archipelago in late 2018 and early 2019. Additional observational activities related to the GCI Cusp topic during other time intervals - such as a sounding rocket mission currently scheduled for 2017 – can also contribute to the overall GCI Cusp project. The GCI Cusp sounding rocket missions will be launched from ASC's Andoya and Svalrak launch sites while data are simultaneously gathered from the ground-based scientific instrumentation available to study the targeted Cusp and related phenomena. Further participation in this exciting new "Challenge" is encouraged and anticipated.

[A-119]

ROCKET MISSIONS FOR CUSP ELECTRODYNAMICS

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As part of the Cusp Grand Challenge, three US rockets will be flown from Andoya, Norway in late 2018 and early 2019. These rockets form the basis of two missions: the Twin Rockets to Investigate Cusp Electrodynamics 2 (TRICE-2) and the Cusp Alfvén and Plasma Electrodynamics Rocket 2 (CAPER-2). The TRICE-2 mission uses a pair of rockets to investigate signatures of magnetic reconnection in the cusp and the CAPER-2 rocket investigates the ionospheric signatures of Alfvén waves and Langmuir waves. The relevant details of both missions will be described including experiment compliment and overall science objectives.

[A-114]

FIRST RESULTS FROM THE SPIDER SOUNDING ROCKET

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The SPIDER sounding rocket was launched on February 2, 2016, from Esrange Space Center, into an active aurora. The rocket carried ten Free Flying Units equipped for measuring electric field and plasma properties in the E region of the ionosphere, with the purpose of characterizing the properties of plasma in the auroral ejectrojet. The payloads reached an altitude of 138 km, crossing regions of auroral precipitation on the upleg and downleg.

In this paper, we present the field and plasma measurements from the free flying units in the context of the ionospheric situation as derived from ground based optical and radar measurements. Considerations for a proposed second flight of the SPIDER payload are discussed based on the experiment performance.

[A-113]

A CASE STUDY OF SOUNDING ROCKET BASED GPS SIGNAL RECEPTION DURING ACTIVE AURORAL CONDITIONS

***Laetitia Jahan*[1], *Philip Conroy*[1], *Yunxia Yuan*[1], *Anna Jensen*[2], *Gabriel Giono*[1,3], *Nickolay Ivchenko*[1]**

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Ionosphere affects the propagation of signals transmitted within Global Navigation Satellite Systems, and the conditions at high latitudes may exhibit large variability due to the effects produced by auroral precipitation. Auroral effects may include localized and transient variations of the total electron content due to ionospheric ionization, as well as signal scintillations due to irregularities in the electron concentration on a range of scales.

A unique opportunity for a case study of the auroral effects was given by the launch of the SPIDER sounding rocket (to be presented in more details in another contribution to the meeting). The SPIDER rocket, was launched on February 2016 in evening sector aurora, reaching an altitude of 138 km in the ionosphere. The rocket ejected ten Free Flying Units (FFUs) which carried plasma instrumentation (electric field experiment and Langmuir probes). The FFUs were also equipped with a trajectory reconstruction system based on data logger recording raw GPS L1 C/A signal received onboard. The recorded data are analyzed post-flight with a software receiver, in order to retrieve observables (pseudoranges and Doppler frequencies) at high resolution for subsequent trajectory solution. The availability of the raw data from multiple closely spaced points enables a detailed study of the signal propagation for the active ionospheric conditions during the rocket flight.

Here we present the case study, employing both the SPIDER GPS data, and ground based GNSS data recorded on dual frequency stations, aiming at an understanding of the signals in terms of the ionospheric conditions, monitored by additional instrumentation.

[A-081]

LANGMUIR PROBES MULTI-POINTS MEASUREMENTS OF THE PLASMA PROPERTIES INSIDE AN AURORAL ELECTROJET RECORDED BY THE SPIDER SOUNDING ROCKET

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The SPIDER sounding rocket, flown in February 2016, released ten Free Flying Units (FFUs) in the ionospheric E region (100 to 120 km) in order to investigate the plasma properties inside an auroral electrojet. In this region, the electric fields result in a relative drift motion of electrons and ions, and induced unstability may create electrostatic waves, in a process refered as Farley-Buneman instability. SPIDER aimed at characterizing such non-linear coupling between the waves on various scales and the electrostatic turbulence by performing multi-points measurements of the bulk properties of the plasma and the electric field.

Each FFUs was equiped with four spherical electric field probes (high impedance probes close to the floating potential) mounted on 2-meter long deployable booms, and four spherical Langmuir probes mounted on 1-meter long deployable boom. Out of the ten FFUs, six were successfully recovered after landing. However, a negative payload charging (around -0.8V) was observed as the FFUs flew through the aurora, resulting in a shift of the Langmuir probe sweeps toward the ion current. Additionally, a larger current than expected was observed, hence saturating the limiting current range of the Langmuir probes (-150 to 250 nA) for many of the bias voltage steps. Nevertheless, some interesting measurements of the current were recorded by the Langmuir probes on four of the six recovered FFUs, for positive bias from +0.1V to +0.7V.

In this paper, a detailed analysis of the Langmuir probes data will be presented, showing the retrieval of the plasma properties in the ionospheric E region for each of these four FFUs.

Technology and Infrastructures for Sounding Rockets 2

Tuesday 13 June, Morning session – part 1

Chair: M. Viertotak

[A-148]

NASA SOUNDING ROCKET PROGRAM AND ORBITAL SCIENCES CORPORATION - NSROC

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The NSROC Program (NASA Sounding Rocket Operations) continues at Wallops Island, Virginia, USA. Orbital Sciences Corporation secured the NSROC III Program and resumed its Programmatic and Technical leadership in 2016. NSROC III continues providing a cradle-to-grave sounding rocket program including mission definition, design, development, integration, test, launch and post-flight analysis for NASA's Sounding Rocket program. The missions support NASA's science disciplines including Geospace, Solar/Heliospheric, High Energy Astrophysics, UV/Optical Astrophysics, Solar System Exploration, Student Outreach and Technology Innovation demonstrations.

Our NASA Sounding Rocket launches are performed from most world-wide launch ranges including Wallops Island Flight Facility Virginia, White Sands Missile Range New Mexico, Poker Flat Alaska, Esrange Sweden, Andøya & Svalbard Norway, Barking Sands Hawaii, Fortaleza Brazil, Vandeburg AFB California, Eastern Test Range Florida, Marshall Islands, Kwajalein Atoll, San Nicholas Island and Kauai Test Facility. NSROC maintains a continued manifest that averages ~20 launches annually.

The NSROC program is highly successful primarily do to the large inventory of rocket motors and hardware, flight proven components subsystems systems, robust designs and large talent pool of experienced engineers and technicians. The NSROC project enjoys a rich heritage of many high fidelity of subsystem designs. NSROC Attitude Control Systems are an excellent example of the high resolution, low cost and high reliability systems to meet the Principal Investigator's science requirements. System capabilities include pointing system accuracies of sub arc-second as common for commonly flown solar and celestial ACS system utilized on the NSROC Program. New developments continue and maintain a legitimate technological base providing investigative capabilities in our earth's exo-atmospheric laboratories.

[A-174]

ARION 1: THE NEXT EUROPEAN AND REUSABLE SOUNDING ROCKET

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In the Q4 of 2018 the European sounding rocket, Arion 1 will have its maiden flight. Arion 1, a liquid-propelled sounding rocket that is being developed by PLD Space, will lift-off from the launch facilities that the company has in the South of Spain, concretely in Huelva.

PLD Space, a Spanish start-up company established in 2011, has been focused during the last years in the development of liquid-propulsion rocket engines that will power their rockets. After having tested successfully the first reusable rocket engine in their facilities at the airport of Teruel, PLD Space is concentrating its efforts in developing the entire Arion 1 sounding rocket.

Arion 1, the first-ever reusable sounding rocket in Europe, will be able to provide around 6 minutes of microgravity conditions after reaching an apogee of 220 km in a nominal mission. This sounding rocket will have the capability of carrying up to 100 kg of payload, exposing the experiments, scientific and technological payloads to low accelerations due to the liquid-propulsion technologies.

With this paper, PLD Space wants to introduce the Arion 1 sounding rocket, its capabilities as well as the advantages of a liquid-propelled based sounding rocket with respect to other traditional space launch systems.

Arion 1 aims to be the sounding rocket reference in Europe, providing affordable, flexible and simple access to space to industry, space agencies, research centres and academia.

[A-095]

STAGE CONCEPT FOR A HOVERING THERMOSPHERE PROBE VEHICLE WITH GREEN, SAFE AND AFFORDABLE GELLED PROPELLANT ROCKET MOTORS

PEDRO CALDAS-PINTO[1], KARL W. NAUMANN[1], JÜRGEN RAMSEL[1], TOBIAS MEYER[1], SEBASTIAN REST[1]

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This paper presents the design concept of a propulsion system for a scientific vehicle for atmospheric research. The specific property is that this vehicle can hover at a required altitude, or scan an altitude range or a lateral range to gather measurements about a selected volume of the atmosphere. The preferred altitude for those measurements is the mesosphere and the thermosphere. This region is too high for ballons but nevertheless of importance for the re-entry of space vehicles. Traditional sounding rockets that can cross this atmospheric layer upwards and downwards yield only measurements along a narrow flight path over a short period of time. Hence, a vehicle that can travel or hover at a required altitude will enhance the measuring capability significantly. As a baseline we assume that the total vehicle mass is about 400 kg which equals the standard payload mass of a VSB-30 sounding rocket assembly. Dependent on the cruise altitude, the vehicle van be launched by a one- or two-stage sounding rocket.

The status of the GRM technology and programme as of 2015 describes Ref. 1, which also outlines some features of the highly controllable GRM. In addition to the wide range of thrust control and stable operation, the GRM produces environmentally friendly combustion products. Our gelled rocket propellant (GRP) itself is as green as propellants can be that are storable at ambient pressure and temperature.

The propulsion concept for the atmospheric research vehicle sounding rocket is not designed for high acceleration. The thrust range is chosen in order to enable the ascent against earth´s gravity or the descent. Given the initial mass of the research vehicle of 400 kg, for this generic case the maximum thrust is set to 10 kN. The lower cost baseline GRM has fixed injectors and nozzle and can be throttled down to less than 1 kN. If the more expensive variant with variable injectors and a variable nozzle throat area a used, a turn-down ratio of about 50 is possible. The GRM is movable for thrust control in two directions. Propellant and pressurizing gas tank are made from carbon fibre reinforced resin. The paper will outline the concept and the functional and performance parameters.

1 K. W. Naumann, P. Caldas-Pinto, J. Ramsel, H. Niedermaier, S. Scheutzow, A. Thumann, " Rockets with Green Gelled Propellants – a Promising Technology for Sounding Rockets", 22nd ESA Symposium on Eur. Rocket and Ballon Programmes, Tromsö, N, 8.-12.6.2015

[A-122]

FIELD VALIDATION OF A SLANT RANGE SYSTEM AT RIO VERDE CAMPAIGN

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On December 07th 2016, the MICROG2 payload was launched from Alcantara (CLA), in partnership with DLR, at Rio Verde Campaign, using the VSB-30 sounding rocket produced by IAE. The onboard telemetry system used a high precision and stable oven-controlled crystal oscillator (OCXO), which allowed the field validation of a slant range unit, developed by IAE and by Brazilian company Delsis.

The slant range unit calculates the distance between the payload and the telemetry antenna based on the delay of the received telemetry signal, which is proportional to the distance. This unit contains an internal PCM decommutator that decodes and synchronizes the received telemetry data, identifies a sync code according to the IRIG-106 standard, and calculates the delay related to a reference frequency generator, which is an ultra stable OCXO. If azimuth and elevation angles are available, the payload trajectory can be calculated and plotted in real time.

The system was successfully used to measure the radial distance from the payload to the CLA Telemetry Antenna during the flight. The payload trajectory was generated and plotted in 3D from the measured distance (slant range), with azimuth and elevation angles provided by the telemetry antenna. The results were compared with radar and GPS references.

[A-050]

WELL-EXTENSIBLE AND CONFIGURABLE IMAGE MONITOR SYSTEM ONBOARD SOUNDING ROCKET

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As with the rapid increase of payloads on sounding rocket, modularized and well-extensible image monitor system shows its huge advantage. This paper introduces modularized image monitor system (MIMS) based on JPEG2000 compression standard.

One MIMS consists of multiple modules which are integrated by multiplexing. The image acquisition can be divided into cruise mode and event mode. MIMS can be compatible with a variety of optical equipment, including HD cameras, infrared cameras, EMCCD, etc. Both analog and digital signal interfaces are supported. The frame rate, compression ratio and other image parameters can be easily configured through a parameter configuration interface in the software according to the demand. So a satisfying image quality can be approached with a limited bandwidth. There is also a temperature monitor module (TMM) based on FLIR (Forward Looking Infrared) camera, which is able to create an image assembled for video output. TMM enables a convinent method to monitor temperature of payloads without physical touching.

MIMS has been successfully worked on the sounding rocket of Chinese Space Environment Vertical Exploration Project (SEVE2) in April 2016. Plenty of images and videos have been transmitted to the ground station.

MAGNESTOSPHERE AND IONOSPHERE 2

TUESDAY 13 JUNE, MORNING SESSION – PART 2

CHAIR : M. LESSARD

[A-040]

KELVIN HELMHOLTZ AND GRADIENT DRIFT INSTABILITIES IN IONOSPHERE CUSP FLOW CHANNELS

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The Investigation of Cusp Irregularities 3 (ICI-3) sounding rocket was launched across cusp flow channels over Svalbard on 3 December 2011. The main objective was to quantify the linear growth rate of the Kelvin Helmholtz Instability (KHI) in connection with reversed flow events (RFE), which is a subclass of transient flow channels in the cusp. ICI-3 resolved substructures inside the RFE, with extreme flow shears ranging from +/- 2 km/s, giving KHI growth times less than one minute. We compare growth rates for KHI with the Gradient Drift Instability (GDI), which appears predominant during most of the flight. While GDI operates across all spatial scales, the KHI mode only operates on scales >1 km. Hence, they may co-exist at scales > 1km. In regions of fast flows and weak density gradients, the KHI becomes faster than the GDI, the previously proposed two-step KHI-GDI mechanism may be of particular importance.

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[A-018]

ON THE ESTIMATION OF ION DRIFT VELOCITY FROM ELECTROSTATIC PROBE DATA OBTAINED DURING ICI-4 CAMPAIGN

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A series of the ICI (Investigation of Cusp Irregularities) sounding rocket campaign has been conducted since 2008 to reveal the controlling mechanism(s) of plasma irregularities and instabilities that generate HF radar backscatter targets and GPS scintillations in the polar ionospheres. The main objective of this campaign is to carry out in-situ measurements of plasma and fields to provide inherent information about the underlying physics of such space weather phenomena.

The 4th experiment of ICI campaign (ICI-4) was conducted in February 2015 to investigate the micro-physics of plasma instabilities and turbulence phenomena associated with the polar cap patches being pulled into the night-time aurora, referred to as auroral blobs. The auroral blobs are created when polar cap patches, islands of high electron density plasma, exit the polar cap in the nightside, *i.e.*, when they are entering the nighttime auroral oval. A total of seven instruments were installed on ICI-4 rocket. Among them, Fixed Bias Probe (FBP) was provided by Japan Aerospace Exploration Agency (JAXA) to measure small scale (< 1 m) density perturbation of electrons and ions.

In the FBP instrument, a spherical probe with a diameter of 2 cm was adopted as a detector for the density measurement of the ionospheric thermal electrons. In addition, two circular disk probes with a diameter of 2 cm were adopted to monitor the local ion density with high-time resolution. The electron and ion probes are biased with a positive voltage of +4 V and a negative voltage of -3 V, respectively, with respect to the rocket potential. The electron and ion currents incident to the probe were used to investigate characteristic feature of electron/ion density irregularity. Another expectation to this instrument is to estimate a direction of ion drift from a spin variation of ion current incident to the disk probes. Information on the ion drift in the polar ionosphere is essential because it is important parameter to discuss a generation mechanism of plasma instabilities such as gradient drift instability and shear instability. In this presentation, we discuss a possibility of the ion drift estimation from the ion current variation. In addition, we will also present characteristic feature of electron and ion density irregularity in the vicinity of the polar cap patches as well as its comparison with the data in ICI-2 and ICI-3 campaign.

[A-149]

FEATURES OF SPORADIC-E LAYER BELOW THE TURBOPAUSE

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It is known that vertical shears in the neutral wind play a major role in the formation of sporadic-E layers at middle latitudes. These layers are controlled by complex dynamics of atmosphere in the mesosphere and lower thermosphere system. Atmospheric turbulence exerts an essential influence on sporadic-E layer if its height is below the turbopause. The turbulence defines both mean characteristics and fine structure of the layer. Intensification of the turbulence has to reduce the peak amplitude of the layer and increases the sporadic-E thickness. In this report we consider theoretically effect of the atmospheric turbulence on sporadic-E mean characteristics, when turbulent diffusion is described by the Richardson–Obukhov law. The consideration was based on three-fluid description of ionospheric plasma. Analytic expressions for estimation of the peak density of sporadic-E and its thickness in the presence of the neutral turbulence were derived. It was shown that the sporadic-E thickness depends on parameters of neutral wind (vertical length-scale, and amplitude of horizontal velocity), ion composition of plasma (through mean ion mass), ion-neutral collision frequency, and diffusivity (the ambipolar diffusivity, if the sporadic-E is over the homopause, or the turbulent diffusivity in our case). The mean rate of turbulent energy dissipation (fundamental parameter of turbulence) reflected an intensity of turbulent mixing. The derived expressions were used to estimate the maximum plasma density in sporadic-E and its thickness when the layer was near 100 km altitude in the mid-latitude ionosphere (magnetic dip of 45o), the sporadic-E ion composition with the mean ion mass about 51 a.u.m., the vertical length-scale of the wind was 10 km and the amplitude of its velocity of 70 m/s, and for the background E-region electron density 3×109 m−3. It was shown that under the change in the dissipation rate from 1 to 10 mW/kg, the sporadic-E peak plasma density has to decrease from 1.2×1010 to 4.0×109 m−3 with increasing its thickness from 1 to 3 km. If the sporadic-E is above the turbopause under the chosen values of parameters the wind shear theory gives the peak density about 7.9×1010 m−3 and the thickness of about 150 m. Thus, the turbulence is very important for the sporadic-E. The result of present report can be tested by rocket or combined rocket-radar experiments that measure simultaneously the winds, turbulence and sporadic-E parameters.

[A-082]

BROR – BARIUM RELEASE OPTICAL AND RADIO ROCKET EXPERIMENT

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BROR experiment aims to study small-scale processes and structure in the auroral ionosphere by the means of an active modification of the ionosphere by multiple release of barium, with modern ground-based observations including updated tomographic observation capability. The project is focused on two specific objectives. During the early stage of the experiment active plasma wave generation and possible conversion of the plasma wave to electromagnetic waves will be studied. In the later stages the fine structure of the electric field and electric current as well as their dynamics in the auroral E-region of the ionosphere will be studied. Both objectives contribute improved understanding of the auroral ionosphere role in the magnetosphere-ionosphere interaction. The scientific payload of the BROR experiment includes four barium-thermite canisters releasing 2 kg barium each, a dual frequency radio beacon at 150/400 MHz, and wave measurement probe (DC-40 MHz). The release of the barium is suggested at altitudes of 120, 140, 160, and 180 km, i.e., E and F1 regions of the ionosphere, much lower than experiments conducted in 1960s and 1970s. Another and the most important advantage of the BROR experiment is an unprecedented support by ground-based instruments and facilities. The successor of the Auroral Large Imaging System: ALIS 4D will be the main optical facility. ALIS_4D is a multi-station, spectroscopic optical imaging system that allows applying tomography-like methods for reconstruction of the 3D-structure of atmospheric optical phenomena such as aurora and artificial radio induced optical emissions. ALIS_4D uses modern imaging sensors that enable high temporal (video rates) and spatial (~50m) resolutions. Optical measurements will be complemented by the all-sky MIRACLE network as well as imagers operated by National Institute of Polar Research, Japan. For the radio measurements we will use EISCAT incoherent UHF radar, dynasonde recently installed in Kiruna, HF/VHF radio emission receivers (SDR), and UHF radio beacon receivers. The aim is to receive funding from the Swedish national balloon and rocket program and launch the BROR experiment from Esrange in the beginning of October 2019 or in the end of March 2020.

[A-133]

RESULTS FROM THE SECOND CHARGED AEROSOL RELEASE EXPERIMENT (CARE II) ROCKET EXPERIMENT

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The CARE II mission was launched from Andoya, Norway, in September 2015. The primary objective of CARE II was to study hypersonic expansion of dust and molecular clouds in the presence of an ambient ionosphere. The CARE II rocket fired 37 rocket motors simultaneously to inject 66 kg of dust particles in the upper atmosphere at an altitude of 266 km (approximately 165 miles above Earth). The dust, composed of aluminum oxide particulates, was accompanied by 130 kg of molecules such as carbon dioxide, water vapor, and hydrogen. The large concentration of dust and exhaust material interacted with the ionosphere to produce dusty plasma with high-speed "pickup ions," a technical term for ionized or electrically charged (positive or negative) particles. The launch occurred just after sunset to place the dust particles in sunlight for easy viewing by cameras in darkness on the ground. Digital cameras were used on a Beechcraft B200 airplane to photograph sunlight scattered from the expanding dust cloud, and the captured images show a dispersal of the dust that appears almost spherical.

The electric field instrument on the CARE II rocket functioned as both a plasma wave sensor and fluctuation monitor. The instrument sensitivity was better than 100 microVolt/m and with a frequency range extending above 10 kHz. The individual samples from eight separate probes in double-double configurations provided multiple baselines for measuring electric fields between sensor pairs. Both low-frequency MHD waves and higher frequency ion waves have been identified in the data. The plasma densities at CARE II instrument payload were measured with electron saturation current fixed-bias Langmuir probes (FLP), a sweeping Langmuir probe (SLP), and an impedance (or resonance) probe (IP). These probes yielded the background plasma before the CARE II release and the density reductions and plasma irregularities excited by the dust and molecule debris injection.

CARE II was supported by ground radars operating in the high frequency (HF) (9 MHz), very high frequency (VHF) (50 Hz), and ultrahigh frequency UHF (914 MHz) ranges. The backscatter data showed no effect at HF, small effect at VHF, and long lived disturbance at UHF. Future analysis will relate the radar backscatter to the plasma disturbance excited by the CARE II release. The ongoing theoretical study of CARE II data is to (1) explain the disturbance observations recorded by the CARE II sensors and (2) predict the magnitude of the plasma turbulence stimulated by the dust injection.

[A-068]

EISCAT INCOHERENT SCATTER RADAR FACILITIES FOR GROUND-BASED ATMOSPHERIC AND SOLAR-TERRESTRIAL SCIENCE IN THE NORTHERN AURORAL OVAL

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EISCAT Scientific Association is an international research organisation enabling fundamental research in solar-terrestrial physics and atmospheric science. At present EISCAT operates three incoherent scatter radar systems (at 224 MHz, 500 MHz, 931 MHz) in the northern auroral zone in Fenno-Scandinavia and in the cusp region on Svalbard. EISCAT also operates an ionospheric heater facility and an ionosonde in Troms.

Scientific applications of the EISCAT instruments include solar-terrestrial physics (direct effects from the Sun on the ionosphere-atmosphere system and those caused by solar wind magnetosphere-ionosphere interaction i.e. aurora), atmospheric physics and global change (dynamics of the atmosphere through 3-D wind vector measurements) and solar system research (such as meteor observations).

In the near future, EISCAT plans to construct EISCAT_3D, which will be a world-leading international research infrastructure consisting of a multistatic phased array radar system (operating at 233 MHz) and a data and computing infrastructure. This will be the first of a new generation of radars whose advanced capabilities will be realised not by its hardware but by the flexibility and adaptability of the scheduling, beam-forming, signal processing and analysis software. EISCAT_3D will be able to operate continuously and carry out simultaneous observations within a large volume of the ionosphere.

The continuous operation and 3-dimensional resolution in a large volume will make the future EISCAT_3D instrument important for detailed studies of how the Earth's atmosphere is coupled to space. An important aim is to understand how natural variability in the upper atmosphere, imposed by the Sun-Earth system, can influence the middle and lower atmosphere. The system will be a versatile monitor of extraterrestrial dust and its interaction with the atmosphere. Mapping of objects like the Moon and asteroids is possible as well. Last but not least the system will enable development of new processing and analysis techniques into standard applications for implementation in the next generation of software radars.

[A-115]

DEVELOPMENT OF A BALLOON-BORNE NIR CAMERA FOR AURORAL OBSERVATIONS UNDER THE SUN

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Imaging aurora in daylight is a difficult and challenging task. The brightness of the sunlight atmosphere overwhelms the auroral emissions at visible wavelengths. From the technical point of view, as long as the auroral signal over the noise (including the sky background) ratio (SNR) is greater than one, the auroral signal can be distinguished. Thus, the challenge is to increase the SNR, which can be approached in two ways. With a given auroral signal intensity, one can only look for where the background sky brightness is lower in sunlight. The possibility does exist according to the atmospheric theoretical models. The other way is to technically reduce the total noise level, so that the SNR can be increased. Such technical improvements include cooling the camera detector array to lower temperatures to reduce the dark current noise, and/or to employ a bandpass filter to reduce the background noise that is generated by the sky brightness. Modeling of atmospheric brightness suggests that the contrast between auroral brightness and sky brightness makes it possible to image the aurora at near infrared (NIR) wavelengths from sufficient altitudes. The auroral N_2^+ Meinel emissions at about 1100 nm are bright enough to be extracted from atmospheric background brightness under the sun at about 40 km of a balloon altitude. Preliminary experiments lead to the development of a NIR InGaAs camera that can be flown on a high altitude balloon.

UTILISATION OF BALLOONS FOR RESEARCH APPLICATIONS 1

TUESDAY 13 JUNE, MORNING SESSION – PART 2

CHAIR: V. DUBOURG

[A-20]

ORISON, A STRATOSPHERIC PROJECT

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This paper reports the outcomes and future prospects of the ORISON feasibility study addressing an observatory-type, regularly flying high stratospheric research infrastructure. The objective of ORISON is to investigate an infrastructure providing a flexible platform, tailored for astronomical use and designed to carry light-weight medium-sized telescopes and other exchangeable instruments. The focus thereby lays on a reusable platform performing regular flights from accessible locations and an operations concept that provides researchers with a similar access to observations using the standard instruments as for ground-based observatories. In addition to a suite of standard telescope instruments, the platform would allow the installation of additional, exchangeable instruments provided by either the operator or as visitor instruments. As such, the ORISON concept aims at complementing the current landscape of scientific ballooning activities by providing a service-centered infrastructure tailored towards broad astronomical use.

The technical implementation that was subject to conceptual analysis assumes broad band telescopes for the ultraviolet to the near infrared spectral regions of the 0.5 m aperture class, combined with sub-arcsecond image stabilisation. In combination with the option to install different instruments, we find such a setup to promise useful capabilities to a wide community while posing manageable technical challenges.

Beyond the technical feasibility, we present the first results of our study on different procurement options for the described infrastructure, including instruments of innovative procurement.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 690013.

[A-182]

ALBEDO MEASUREMENT USING PHOTODIODES ON A HIGH ALTITUDE BALLOON

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The surface albedo of Earth was named as one of the essential climate variables (ECV) by the Global Climate Observing System in 2003. The reason for this is strong impact of albedo in terms of radiative forcing. Especially the effects of the albedo in the arctic, e.g. with the ice-albedo feedback loop, play an important role and need to be investigated further. The land surface albedo is usually investigated using satellite measurements. In the last years many improvements to the estimation of albedo using satellite measurements have been made. Especially the development of bidirectional reflection distribution models, that were developed alongside MODIS, have contributed a great deal to the improvement of albedo estimation. However, the estimation is not perfect and still needs improvement.

Bond Albedo is defined as the ratio of incident and outgoing radiation. Therefore we are planning to take direct albedo measurements with a high altitude balloon as part of the BEXUS 25 mission. In order to take the measurement, we employ two sensor boxes with multiple photodiodes. One of the sensor will be looking upwards, while the other will be looking downwards. This will allow us to find the ratio of incident and outgoing light. We will take measurements in the entire visible range as well as in the IR up to 2.5μm. Additionally we will have photodiodes for more specific spectral ranges, such as green light around 500nm. This will allow us to obtain more information about the surface properties. For example, the red edge can be observed using the red and NIR spectral bands. With these direct albedo measurements the albedo estimates by satellites should be improved.

The experiment is made in a straightforward way, so that it can be easily flown more than once and on smaller balloons as well. That would give more data and more accuracy for the improvement of satellite models and could also lead to long-term measurements of arctic albedo measurements. Which could give more clarity about possible long-term trends.

[A-162]

CNES SUPER PRESSURE BALLOONS UPGRADE FOR STRATEOLE-2 CAMPAIGN

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The French Space Agency, CNES, has developed, since about twelve years ago, super pressure balloons (SPB) that float on constant density (isopycnic) surfaces in the lowermost stratosphere, carrying 40 to 50 kg payloads, during typically three months. These SPB have been successfully deployed in flotilla of about 20 balloons for different scientific campaigns all over the world in different configuration sizes from 8,5 to 12 m diameter, mainly to document the chemistry and dynamics of the atmosphere, to study gravity waves, and to provide in-situ atmospheric profiles thanks to the NCAR driftsonde payload.

The SPB housekeeping gondola used from 2005 to 2011 now needs to be upgraded in order to increase the flights' safety and to improve its performance with up to date equipment's. The control center will also be redesigned. These modifications take into account the experience acquired during the last SPB campaigns, mainly during CONCORDIASI, with 19 flights over Antarctica from September 2010 to January 2011. After a successful preliminary design review, the project is now conducting the detailed conception phase.
This new system is developed for STRATEOLE-2, a project dedicated to the coupling processes between the troposphere and the stratosphere in the deep tropics, using several types of instruments, both for in situ and remote measurements in the atmosphere. STRATEOLE -2 includes two measurement campaigns, three years spaced to study the quasi biennial oscillation. Since the scientific payloads are fully self-standing, some technical solutions will be common with the CNES housekeeping gondola, such as the renewable power system.

This paper will describe the STRATEOLE-2 project and the developments in progress for the SPB system upgrade.

[A-134]

STATUS OF NASA'S GHAPS PROJECT: GONDOLA FOR HIGH-ALTITUDE PLANETARY SCIENCE

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NASA's GHAPS project (Gondola for High-Altitude Planetary Science) is intended to be a shared resource for the planetary science community, providing hundreds of hours of observations from a near-space environment. The GHAPS science payload will be a 1-m aperture f/14 Ritchey-Chretien telescope with one or more science instruments. At the time of this writing, there is an open solicitation for the science instruments. The notional capabilities of the instrument package will likely include diffraction-imited imaging at 500 nm and infrared imaging and spectroscopy at 1 – 5 µm.

The first GHAPS flight is expected to be a zero-pressure flight (reaching altitudes around 38 km), launched from Ft. Sumner, NM in the fall of 2019 with a duration of 8 – 24 hours. This initial flight will be followed by five long-duration super-pressure flights (altitudes near 33 km) of up to 100 days, beginning in 2020 and proceeding at one flight per year. The super-pressure launch site will likely be in New Zealand. The super-pressure flights are expected to provide up to 1000 hours of nighttime observing.

This talk will cover some of the specific design decisions and challenges being considered by the GHAPS team. Specific topics will include coarse and fine stabilization of the telescope and focal plane, passive temperature control of the telescope and in-flight assessment of the wavefront error.

[A-126]

POGO+ THE SWEDISH NATIONAL TRANSATLANTIC BALLOON MISSION

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The PoGO+ is Swedish national stratospheric scientific balloon mission launched from Esrange by SSC.

PoGO+ was launched 2016.07.12 03:17 UTC. Due to a cold stratosphere the ascent was slow and a initial float altitude of 39 936m m was reached 2016.07.12 13:21:22 UTC on at an ascent speed of approximately 2,6 m/s. The flight was terminated by command 2016-07-18 21:38 UTC and impact was 22:26 UTC (after 6 days and 19 hours of flight) at latitude 71.84747 longitude -110.885 on Victoria Island. The payload mass was 1728 kg and an SF-39.57 balloon was used.

PoGO+ is a stratospheric balloon project with an experiment from KTH, Stockholm, Sweden. PoGOLite flow prior to the 2016 campaign in 2013.07.12-26 from Esrange to Norilsk in Russia in a circumpolar flight over Canada.

The PoGO+ is a balloon-borne hard X-ray polarimeter operating in the 25 - 240 keV energy band from a stabilised observation platform. Polarisation is determined using coincident energy deposits in a segmented array of plastic scintillators surrounded by a BGO anticoincidence system and a polyethylene neutron shield. Observations were conducted from a stabilised stratospheric balloon platform at an altitude of approximately 40 km. The primary targets are the Crab - a pulsar and associated wind nebula in the constellation of Taurus, 6500 light years from Earth, and Cygnus X-1 - a black hole binary system. An pointing system keeps the polarimeter field-of-view aligned to targets of interest, compensating for sidereal motion and perturbations such as torsional forces in the balloon rigging.

The mission was very successful with all systems both scientific and support and balloon systems working nominal during the complete flight. A huge amount of scientific data was collected during the flight that will be analysed. The flight lasted 6 days and 19 hours, this was longer than expected resulting in more scientific data. The landing and recovery was performed nominal and the scientific data were recovered and delivered to the science team within 12 days after landing.

The mission is managed by SSC and SSC is responsible for gondola structure, housekeeping and communication systems, power systems and part of balloon flight systems. SSC is handling the launch, flight and recovery. KTH is responsible for the instrument, X-ray polarimeter, including all subsystems for controlling and monitoring the systems including thermal management. DST Control, Sweden is responsible for the dual axis pointing system.

[A-177]

THE PACKMAN RADIATION AND ENVIRONMENTAL INSTRUMENT FOR SPACE WEATHER STUDIES.

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To date, there is a missing gap of information regarding the amount, energy, time variability, and type of space radiation that reaches the lower layers of the atmosphere, as well as on its geographic and altitude distribution, and thus there is no real understanding about the role of space weather on the Earth´s atmosphere, and of its potential impact on infrastructures and climate.

On present day, there are unfortunately very few Earth surface radiation monitors (neutron detectors mostly, and very rarely muon detectors) and they are unevenly distributed. They are operated by scientific institutions, their data are hard to interpret by the non-expert user, they are generally not public and are not delivered in real time. Furthermore, to date, there are very scarce balloon measurements of radiation profiles in the atmosphere. This impedes having an adequate knowledge of the impact of space weather phenomena on terrestrial infrastructures and climate. The role of latitude and local geomagnetic anisotropies on the amount of radiation that reaches the surface has also been very poorly investigated. To mitigate this, we are designing a low-cost robust radiation and environmental instrument that can be operated anywhere on the planet surface and low atmosphere.

The PACKMAN (PArticle Counter k-index Magnetic ANomaly) prototype is a small, robust, light and scalable instrument that monitors continuously gamma, beta, alpha radiation and muons. This instrument includes environmental sensors to monitor pressure, temperature, relative humidity, and magnetic perturbations and includes data archiving, GPS and communication capabilities. Through the deployment of multiple ground-based PACKMAN units we shall generate a network of surface instruments that acquires the same observational data set. In addition, we intend to launch similar PACKMAN units within balloon platforms in a set of predefined campaigns (circumpolar, and tropospheric soundings) to investigate in-situ the vertical profiles of radiation in the atmosphere in the polar region. The joint analysis of the measurements from these campaigns, both in-situ and on ground, with existing orbiter instruments (such as GOES) will improve our understanding of the role of space radiation, from galactic cosmic rays to solar energetic particles, on the Earth atmospheric physics and chemistry. This network will provide real-time, open-policy access to a standardized data set of radiation and environmental measurements, at multiple sites. Besides its basic scientific use, the data of this project can be used to educate and engage the public, or other industrial actors on space weather research.

RANGES FACILITIES 2

TUESDAY 13 JUNE, MORNING SESSION – PART 2

CHAIR : L. POROMAA

[A-084]

THE NEW OLD PROCESS OF ROCKET WIND WEIGHTING

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Wind weighting is the process of correcting for impact point displacement due to wind effects during sounding rocket launches.

At Esrange Space Center we use the application *Storm* for wind weighting. Storm implements the historically proven Lewis method for launcher setting corrections.

SSC developed Storm as a part of our effort to rejuvenize and future-proof our safety software suite. It has been fully operational since late 2015 and used during rocket launches at ESC as well as in Woomera, Australia.

Storm depends on services provided by the application *Breeze,* which collects wind measurements and forecasts, refining these for usage by other applications.

These applications were designed with extensibility and maintainability in mind, while providing both internal users and customers with highly valuable visualizations of predicted and current launch conditions.

[A-088]

ORIENTATION CALCULATIONS USING 3-AXIS MAGNETOMETER

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Andøya Space Center Hotel Payload standard configuration includes a 3-axis magnetometer integrated in the payload. The magnetometer has a high sampling rate (2890Hz for MaxiDusty campaign in 2016), provides us with accurate measurements of the magnetic field vector components along the magnetometer axes and represents a low-cost solution in terms of both the cost of the device and integration effort. Together with a magnetic field model, we are given the possibility to perform postflight calculations of the actual orientation of the payload.

The solution has proven to be accurate for determining the apparent spin frequency of the payload with minimal post-processing effort. The calculated orientation of the three magnetometer axes are typically less than 2 degrees from the measured values converted to angles, indicating that the accuracy is good. However, since the device itself is positioned inside a rotating metallic cylinder, we also need to correct the calculated orientation for the induced magnetic field.

Mathematically we are modelling the payload as a *spinning top* with the spin-axis aligned with the longitudinal symmetrical axis of the payload and the precession axis, representing the coning of the payload, assumed to be aligned with the velocity vector at non-negligible atmosphere and constant above it.

We will here briefly present the mathematical framework, including necessary coordinate systems, on which the calculations are based. Uncertainties introduced by the different calculation steps and assumptions are identified and described. We will also compare the calculated orientation with sun-sensor data for some of the campaigns conducted from ASC with such data available.

[A-124]

EUROLAUNCH – A COOPERATION IN CHANGE

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EuroLaunch is a long-standing and successful cooperation between SSC's Esrange Space Center and DLR's Mobile Rocket Base. Both organisations have recently celebrated their 50th anniversary. The collaborative coordination of services and infrastructures has provided an efficient, cost effective and flexible partner for sounding rocket and balloon missions from Esrange.

The *EuroLaunch* cooperation was officially established in 2003 and has demonstrated its valuable contribution to science during many joint projects. Since the last ESA PAC Symposium in 2015, the following projects have been carried out jointly: REXUS/BEXUS, O-STATES 1/2, MASER 13, SPIDER, HIFiRE 5B, ROTEX-T, and STERN.

DLR and SSC will continue through *EuroLaunch* to create synergies to the benefits of the customers and raise the cooperation to the next level, which is the foundation of a joint company scheduled for the fourth quarter of 2017. The aim is to foster the standardization of sounding rocket systems and to offer frequent flight opportunities with ready-to-fly launch vehicles. At the same time, the services are offered in the form of a flight ticket with one contact point to the customer.

The *EuroLaunch* entity proposes best value for money for all its customers and is open for strategic partnerships.

[A-120]

ESRANGE SPACE CENTER –NEW TELECOMMAND SYSTEM

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The new Telecommand system at Esrange Space Centre was installed in autumn of 2016, and it replaces an old Telecommand system that has been in use since 1988.

For sounding rocket microgravity operations, both Scientific and Range Safety commands are used.

The system can and must be able to handle the two cases simultaneously and independent of each other.

For FTS operation the system is designed to meet RCC 319-92 Standard, Flight Termination System Commonality Standard.

The new system is designed for fully redundancy and higher outputpower compared to the old system.

[A-060]

ARTIFICIAL NEURAL NETWORK FOR RANGE FLIGHT SAFETY

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Important space technologies activities can be developed by microgravity experiments during suborbital rocket flights. Since they return to surface, their launch operations demand an accurate Earth Impact Point prediction. This is due not only because of one certain mission characteristic, like a payload recovery, but mainly to ensure the Operational Flight Safety. Many factors influence a launch trajectory, deviating the rocket from its nominal and changing its Impact Point. Among them, the main factor to be analyzed is the wind effect. This paper presents the wind compensation method today used at Alcantara Launch Center and propose a new improved method. The first, Guará Method, is based on the presented by J. V. Lewis in 1949, which is used on many ranges around the world with its specific adjustments. It follows the execution of three steps: 1) the wind profile identification, 2) the Impact Point displacement calculation caused by these winds and 3) this displacement compensation with a new launcher setting. The second, ANNA Method, is based on the previous learning of an Artificial Neural Network created after tens of thousands of simulations using the 6 DoF rocket simulator ROSI. With this Method, the Range Flight Safety Officer has a robust yet simple formulation to obtain, in real time, the Impact Point prediction and launcher settings. It was used as a case study the VSB-30 rocket ROSI model, as used at the Rio Verde Operation, occurred in November 2016 at CLA, and the wind data collected during that month. An adimensional error function was defined in order to compare both methods considering the azimuth and range errors. The cases presented in this paper shows a significant improvement of the Impact Point prediction and launcher settings when using the new ANNA Method.

[A-121]

ESRANGE SPACE CENTER –

NEW TELEMETRY STATION AT ESRANGE SPACE CENTER

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The reconstruction of the telemetry station for sounding rockets and balloons at Esrange has been going on since 2012. There are many reasons why it was needed: to get a higher security level on the optical cables, computers, network switches, to get a more efficient signal distribution to customers, switching of telemetry data, to manage simultaneous campaigns and to get a quiet control room for the operators, especially during long balloon flights.

TMS – Telemetry server room with 6 racks was created for our computers, network switches and optical fiber cables.

The analogue TV-receivers were moved to the common TV- center together with DLR.

A room for balloon sounding and a RF – laboratory was built.

TMR – Telemetry receiver station was constructed and all equipment was moved behind a glass wall.

The signals are routed logically from left to the right: Antennas, RF-matrix, receiver, analogue video matrix, analogue video, digital matrix, digital RS422/TTL, TM over IP network.

The telemetry data distribution to customers are analogue video, digital RS422/TTL or via network. We use HDD recording with chapter 10 format for recording of: RF- IF, video and digital sources.

TMC – Telemetry control room are equipped with three ACU - Antenna Control Unit's. The EMP antenna is on the roof of the main building. The Datron antenna is on Keops hill and the new Orbit antenna is situated on radar hill.

From the control room we can easily switch antennas and distribution of telemetry signals via the switch operator location.

Vaisala meteorological soundings can be monitored from the TM station as well.

[A-156]

ESRANGE SPACE CENTER – LATEST HIGHLIGHTS AND FUTURE PLANS

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After the last ESA-PAC meeting in Tromsö, in the summer of 2015, three balloon campaigns were performed for ESA, JAXA and NASA. The ESA campaign was first, and three drop tests of re-entry bodies were made for ESA from balloons at 30 km altitude. It was followed by the second flight of JAXA's supersonic test aircraft, looking at the sonic boom generated. Last but not least, the NASA funded BARREL scientific balloon campaign, studying electron losses, flew 7 balloons during turn-around with the longest flight measuring just over 36 hours. A new satellite based secondary cut-down and positioning system was developed for the BARREL campaign.

October was a busy month with four campaigns – two BEXUS student balloons, four German student rockets, two Swedish scientific rockets and a Swiss balloon campaign with 9 small balloons dropping autonomous aircraft. The German student rockets all used hybrid motors, which was a first for Esrange.

2015 was then wrapped up with the ESA funded MASER 13 rocket campaign.

The first half of 2016 started off with five rocket campaigns – one national German TEXUS rocket was launched, follwed by a Swedish rocket. Two Swedish/German REXUS student rockets followed after which the national German and French student programmes launched two and one rocket, respectively.

In the summer 2016 the second flight of the Polaraized Gamma Observatory (PoGO) was performed. Launched in mid-July, the balloon flew for 7 days from Esrange to Canada, with excellent perfomance. The balloon flew with some new flight equipment, including a satellite-based telemetry system with up to 100 kbps data rate.

The German scientific rocket ROTEX-T was launched in July. It was the first time a Terrier-Improved Orion combination was launched at Esrange.

France returned to Esrange for the first balloon campaign since 2011 in August, launching two payloads. For the second year, NASA funded a second BARREL campaign with eight payloads that also were flown during the same month.

2016 was ended with two student campaigns – two BEXUS balloons and two German student rockets.

This year so far has seen one rocket launch. MAIUS, launched in January, carried one of the most complex experiments so far from Esrange. In the rocket payload, an Einstein-Bose Condensate was created for the first time in microgravity. For a short while one of the coldest spots in the universe existed on-board a rocket from Esrange.

ATMOSPHERIC PHYSICS AND CHEMISTRY 2

TUESDAY 13 JUNE, AFTERNOON SESSION – PART 1

CHAIR: B.STRELNIKOV

Plenary Invited Lecture

[A-129]

NEW SYNERGIES OF SOUNDING ROCKETS AND REMOTE SENSING IN THE UPPER MIDDLE AND LOWER UPPER ATMOSPHERE

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"Whole atmosphere thinking" has opened exciting new research perspectives to the mesosphere and lower thermosphere. Old dividing lines between research communities below and above 100 km have been softening, and new studies have emerged that combine experimental or theoretical techniques from different fields. Resulting scientific questions concern a wide range of phenomena, and interactions over a wide range of spatial and temporal scales. An important key to these questions is the combination of remote sensing and in-situ measurements. As for ground-based remote sensing, the implementation of relevant instrumentation has long been a major driver for the development of Andøya Rocket Range and Esrange Space Center, with outstanding scientific results. Beyond current local instrumentation, EISCAT_3D will soon open new paths of collaboration between the rocket ranges and a research infrastructure that involves the Nordic countries. As for space-based remote sensing, possibilities of directly combining sounding rockets and satellites are more limited, as truly coincident and common volume measurements are difficult to achieve. Nevertheless, a more general combination of complementary rocket and satellite results has been an important source of new knowledge in many areas. Other synergies concern the use of sounding rockets for pre-launch testing or in-orbit calibration of satellite instruments. At the same time, a seemingly limitless push for CubeSats can today be perceived as a major threat to future sounding rocket programmes. In a time of unknowns, this presentation tries to share some thoughts about current developments and perspectives.

[A-076]

CHARACTERISTICS OF POLAR MESOSPHERE SUMMER ECHOES DURING THE MAXIDUSTY CAMPAIGN AT ANDENES, NORWAY IN SUMMER 2016

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In summer 2016 the MAXIDUSTY sounding rocket campaign was conducted at the Andøya Space Center. MAARSY was operated to detect and observe polar mesospheric summer echoes (PMSE) with multiple beam directions to propose favorable launch conditions. A dedicated experiment configuration with 21 different beam positions was used to point the radar beam along the predicted trajectory of the payload. This special radar experiment allowed a) to derive detailed information about the spatial structure of the PMSE around the flight of the rocket, b) common-volume observations on upleg within the PMSE layer and c) the determination of horizontal winds in the PMSE altitude range. Furthermore, the Saura MF radar was operated during both flights probing the mesosphere with a multiple beam scan experiment to derive wind and electron density profiles. The second launch seems to be particularly interesting as it was conducted in between of two minor particle precipitation events causing enhanced electron densities at 70km and above. The obtained PMSE characteristics will be discussed on the basis of signal strength and spectral width of the received radar signals as well as estimated horizontal and vertical winds with particular emphasis to the launch times of sounding rockets. Results from the DUSTY rocket probes, measuring the dust charge density along the rocket trajectory, will be compared with the radar measurements.

[A-028]

COLLECTION OF STRATOSPHERIC AEROSOL PARTICLES DURING THE BEXUS 20 BALLOON CAMPAIGN BY TEAM COSPA

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Aerosol particles were collected during the BEXUS 20 balloon campaign (Kiruna, 2015) by the team COSPA (COllection of Stratospheric aerosol PArticles) with the Micro INertial Impactor (Multi MINI). The particle collector consists of 12 single micro inertial impactors and can be operated manually. It is additionally equipped with a 13th mode, allowing to flush the inner tubes with ambient air in order to avoid contamination from ground.

The particles deposited on two stages with cut off diameters of 500 nm and 10 nm. The large fraction impacted on boron grids for subsequent scanning electron microscopy (SEM), the small fraction on Ni-Transmission Electron Microscopy (TEM) grids. The manual operation of the impactor during flight allowed the collection of eight samples: First, the launch of the balloon from ground, second a sample above the atmospheric boundary layer to the tropopause at 13 km, third: the tropopause, fourth: lower stratosphere, five-eight: float in the stratosphere at 28 km. The particles from the samples were analyzed by SEM and TEM both equipped with Energy Dispersive X-ray microanalysis systems (EDX). Thus, information on particle size, chemical composition and morphology was obtained.

In all samples, volatile particles were dominating the particle number. In the troposphere, the particles basically consist of S and O, which is interpreted as sulfates/sulfuric acid. In the tropopause at ~13 km, the particle chemistry is dominated by N and O, whereas a smaller amount of S still occurs. Thus, the particles are interpreted to be mixtures of sulfates and nitrates. In the stratosphere, nitrates dominated over sulfates. Compared to the sulfates, the nitrates were less volatile to the electron beam and left behind a characteristic residuum. An additional occurrence of Cl was identified. The exact chemical compound of elements N-O-S-Cl still remains unknown.

In the troposphere, few refractory soot particles, characterized as several aggregated primary particles with an onion-shell like microstructure are encountered. In the stratosphere, refractory particles in the size range << 100 nm internally mixed with the volatile nitrates occur. The particles are mainly either Mg-rich silicates or Fe/Mg-rich silicates. Some of the particles contain additional Al. The particles are aggregates of several spherical particles with d=10-50 nm.

[A-042]

ESTIMATES OF THE SIZE DISTRIBUTION OF METEORIC SMOKE PARTICLES FROM IN SITU MEASUREMENTS WITH DUST IMPACT PROBES

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Mesospheric ice particles of sizes larger than a few nanometers have been suggested to contain meteoric material with volume filling factors up to several percent. Meteors ablate in the 70-110 km altitude region and re-condense to meteoric smoke particles (MSP) of sizes up to a few nanometers. These particles are likely to stick to water ice and accelerate growth rates of mesospheric ice particles. This work reports on measurements done with two triplets of the rocket-borne instrument MUDD (Multiple Dust Detector), which were launched from Andøya Space Center in the summer of 2016, on two respective payloads during the MAXIDUSTY campaign. The probes are of the Faraday-bucket type with an impact grid that fragments incoming ice particles of sizes larger than ~10 nm and releases a fraction of the embedded MSPs. By varying electric fields between a detector plate and the impact grid, an estimate of the fragment size distribution can be obtained. We argue that the detected fragment currents should be dominated by pure MSPs, and find that they follow inverse power laws of exponents $k \sim 3.6 \pm 0.7$ and $k \sim 4.6 \pm 0.9$ for the respective rocket flights. This result remains valid when charging probabilities of fragments are ~0.1 and only a few percent of embedded MSPs are released in the collision.

[A-086]

A NEW ROCKET-BORNE METEOR SMOKE PARTICLE DETECTOR (MSPD) FOR D-REGION IONOSPHERE

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Meteor Smoke Particles (MSP) in the D-region ionosphere at polar latitudes are thought to play an important role in the formation of Polar Mesospheric Winter Echoes (PMWE). PMWE are strong radar returns from altitudes between 50 and 85 km observed at high latitudes in both northern and austral hemispheres. Their formation mechanisms were suggested based on experimental data obtained from remote soundings and some in-situ measurements and still under debate. The in-situ data during PMWE events is very limited and does not include measurements of MSPs. Moreover, the existing in-situ measurement techniques of MSPs are drastically affected by aerodynamical filtering of the smoke particles at altitudes below about 80 km.

In this paper we introduce a new rocket-borne Meteor Smoke Particle Detector (MSPD) for the D-region ionosphere. Its geometry was optimized based on numerous combined aerodynamic and electrostatic simulations to allow for detection of tiny MSPs at altitudes below 80 km. We also show the deduced collection efficiencies as dependence of MSP-mass and altitude.

Technology and Infrastructures for Sounding Rockets 3

Tuesday 13 June, Afternoon session – part 1

Chair: O.R. Enoksen

[A-154]

MAKING THE CASE FOR SOUNDING ROCKET GUIDANCE SYSTEMS

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Guidance systems have been used successfully on hundreds of sounding rocket missions for over 40 years. The primary reason for adding a guidance system was mission requirements which aimed for a much higher apogee while at the same time the level of impact dispersion had, for safety reasons, to be kept in check. For missions launched over a land based range like Esrange and White Sands Missile Range this is of paramount importance.

There are other compelling reasons to include a guidance system as well, related to the guided vehicles' reduced sensitivity to wind, which has a positive effect on the planning of the launch campaign. Being virtually unconstrained by the wind conditions means that launch can be conducted on the planned date, and additional campaign days at launch site becomes exceptional. Moreover, scientists can with high confidence plan their stay at launch site to be present for launch and post-launch activities. Biological experiments that require short turn-around time have significantly higher chance of success.

Guided sounding rocket missions need additional system solutions compared to an equivalent unguided mission; besides the obvious need for a guidance system, a Safety Operation system including thrust termination system has to be put in place as well as additional flight trajectory tracking means to fulfil safety requirements.

RUAG Space currently provides three types of sounding rocket guidance, navigation and control systems: The S19L - to be superseded by the electrical version S19E, which uses aerodynamic canard control, the thrust vector control system GCS and the cold gas Spinrac system for exo-atmospheric impact point control and payload pointing. Over time, all these systems have become more capable, their mass and cost have decreased.

Esrange safety requirements call for use of guided vehicles for missions with 1-sigma dispersion values larger than approximately 20 km – typically for apogees above 270 km. The first four missions within SSC's MASER programme, providing 7 minutes of microgravity, were guided missioins attaining 300 km apogee. Also missions not obliged to be guided would benefit from the use of guidance system, as campaign duration would be shortened, and follow-on missions would not risk to be shifted to later dates, as often is the case with preceding extension of launch campaigns due to high winds.

This paper aims at taking a holistic view on guided sounding rocket missions, further discuss the benefits of guided vehicles and how the additional system solutions can be put in-place in a cost-effective manner.

[A-161]

HIFIRE 5 AND 5B – HYPERSONIC FLIGHT TRIALS FROM ANDØYA TO WOOMERA

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The Hypersonic International Flight Research and Experimentation (HIFiRE) is a joint program of the US Department of Defense and Australian Defence Science and Technology Group (DST Group). The purpose of this program is to investigate fundamental hypersonic phenomena by using an affordable, accessible, prototype experimentation strategy.

DLR Mobile Rocket Base and DST Group initiated a cooperation for the conduct of sounding rocket missions within the HIFiRE program. This included the provision and adaptation of the two-stage launch vehicles, as well as the joint mission development and launch preparation in cooperation with the launch base operator and DST Group.

The HIFIRE 5 payload is a squashed cone experiment for the measurement of hypersonic boundary-layer transition on a three-dimensional body. HIFiRE 5 was launched in April 2012 from Andøya Space Center in Norway, but the second stage motor on this flight failed to ignite. As a result, the experiment reached a maximum Mach number of 3. Nevertheless, supersonic pressure and temperature data were obtained under laminar and turbulent flow and flight systems were validated.

An investigation identified the root cause of the ignition failure and a re-flight from the Australian launch base *Woomera Instrumented Range* (WIR) could be implemented. The resumption of flight experimentation trials in Woomera after a long haul of almost 10 years was demanding for all groups involved, but the combined team of Australians (DST Group, WIR), Americans (ARFL, NASA), Germans (DLR Mobile Rocket Base), Swedes (SSC Esrange Space Center) and Norwegians (Andøya Space Center) managed all challenges with flying colors.

HIFiRE 5B was successfully launched on 18.05.2016 and all scientific and technical goals have been achieved.

[A-074]

DESIGN AND QUALIFICATION OF A NOVEL PYROTECHNICAL RELEASE SYSTEM FOR SOUNDING ROCKETS

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Separation mechanisms are integrated parts of the payloads and completely necessary for separating the nose cone and doors in order for the instruments to deploy and carry out their measurements in the atmosphere. Similar mechanisms are used for separation of the payload from the motor. The separation mechanisms have traditionally a pyrotechnic device (squib) mounted at the end of a cylinder and a piston moves a knife blade that cuts one or several screws or wires causing the nose cone or doors to separate.

In later years, the price on American manufactured squibs have increased. These pyrotechnic devices used for separation mechanisms amounted in 2014 for 30% of the total hardware cost for a sounding rocket payload. A more cost effective solution was favourable and the use of gas/gunpowder used in airbags were looked into. At the same time the development of the necessary electronics were carried out. The main goal was a cost saving of 90%.

Several suppliers of airbag igniters and appropriate connectors and harnesses have been considered. Airbag igniters have been tested cutting a steel wire using a slightly modified wire cutter design. The new and old design are quite similar with a small difference in the squib retainer, which is the part holding the squib in place. A different retainer was made to hold the airbag igniter.

In the testing 100% of all wires were cut and the solution will be tested on a launch in September 2017. The main goal of a cost saving of 90% were achieved.

[A-097]

NAMMO SPACE PRODUCTS AND ACTIVITIES

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Nammo Raufoss is long time player in space, producing high-quality solid rocket motors, safe & arm devices and various mechanical parts for the Ariane 5 family of launchers. As the Ariane 5 launcher is coming to an end, Nammo started over a decade ago with activities to pursue new markets. Hybrid rocket propulsion was the first technology to set sail. The interest in this type of propulsion emerged from the possibility to develop rocket motors that could be thrust modulated and restarted on demand while maintaining a green and non-pyrotechnic nature, qualities virtually impractical in solid rocket motors. Keen interest from Andøya Space Center and ESA sparked the initiative to work on hybrid propulsion systems for both sounding rockets, micro-launchers and distancing rockets for launcher upper stages. In 2007 Nammo flew its first hybrid rocket from Andøya Space Center, Norway.

The flight success paved the way for a new generation of hybrid rocket propulsion based entirely on long-term storable propellants, mainly the liquid propellant hydrogen peroxide. The new generation of hybrid rocket motor architecture is developed entirely by Nammo with initial support from SAAB Dynamics on hydrogen peroxide.

Entring hydrogen peroxide business led to the building of a unique test and storage facility at Nammo's own test center. The facility can hold up to 20 tons of rocket grade hydrogen peroxide and can be used for static testing of rocket motors with thrust levels up to 500 kN. The facility is operational since 2012 and with this Nammo is pursuing programs of up-scaling hybrid rocket motors to larger scales in order to meet the demands of the sounding and launcher markets.

Hydrogen peroxide serves also as a green and clean monopropellant in Nammo's activity on reaction control systems. Recently Nammo were in full-scale development of an advanced Hot Gas Reaction Control System for the now cancelled Ariane 5 ME launcher. The focus today is on the development of similar systems for VEGA launchers and possibly for the Space Rider spaceplane.

Nammo is also active in several studies and smaller technological programs dealing with micro-launchers, advanced long duration hybrid rocket motor developments to propulsion systems for deorbitation of satellites.

Nammo's excellence in solid rocket propulsion is not forgotten. Today Nammo is developing the igniter for the P120C solid rocket booster, to be used in both VEGA-C and Ariane 6 launchers. In addition Nammo is to develop the distancing rocket motors for the separation of the P120C booster from the Ariane 6 launcher, thus continuing our proud and successful business as done for two decades for Ariane 5.

PICO Sessions

Tuesday 13 June, Afternoon session – part 2

Chair: A.Kinnaird

[A-054]

BALLOON GRADIENT MAGNETIC MEASUREMENTS AND SATELLITE MAGNETIC SURVEYS SYNERGY

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The stratospheric balloon magnetic gradiometer has been developed at the Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation of Russian Academy of Sciences (IZMIRAN) and the Moscow Aviation Institute (MAI). It has two-stage measuring base of 6 km general length, oriented along the vertical line by means of the gravity. Measuring the balloon base, located at the altitude of 30 km, allows obtaining the geomagnetic field gradients (GMP) from sources up to the lower boundary of the Earth's crust. It is shown that in Russia the vertical gradients of anomalous GMP at the altitude of 30 km have an average value of 2,5 nT / km, while the average value of the magnetic anomalies in the region amounted to 50 nT. For anomalous GMP area larger than 100 km, where it is no significant magnetic anomalies, is found. For these areas to assess the magnitude of the main GMP a comparison of the measured data and simulated balloon based IGRF model is carried out. Satellite data provide a deep anomalous GMP mapping irregularities of the earth's crust in the global view, which contributes to the prediction of mineral fields. Using aerostat magnetometer system provides data anomalous GMP in a limited amount of space than with the satellite measurements. Wavelet analysis of the balloon-borne and ground-based magnetic profiles and compare the results with satellite data showed that the aeromagnetic data does not fully contain the magnetic field of deep sources and balloon data contain all the magnetic field of the Earth's crust sources in significant quantities. Using balloon and satellite magnetic data provide a synergistic effect, allowing you to refine the process of formation of satellite magnetic anomalies and investigate the deep structure of the Earth's crust in the global and local views, consider the representativeness of the main model GMP, a detailed examination of three-dimensional structure of the external GMP, which is important for type "Swarm" projects.

ASTROPHYSICS

[A-145]

MECHANICAL DESIGN AND THERMO-ELASTIC ANALYSIS OF THE PILOT INSTRUMENT

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PILOT is a stratospheric balloon-borne experiment to measure the polarization of dust emission in the diffuse interstellar medium with an image quality of a few arc-minute in angular resolution.

It is designed to fly at a ceiling altitude of about 4hPa pressure to reduce contamination of the astronomical signal by the Earth's atmosphere. Its mechanical structure is studied to preserve the image quality at ground test and in flight environment.

I present the mechanical design with 3D modeling, finite elements analysis, and thermo-elastic study, and I compare the results before and after the first flight, that took place on September 2015 at Timmins; Ontario, Canada. And finally, I'll give the performance estimation for the future second flight.

[A-047]

EXPERIMENTAL FINDINGS ON FLAME PROPAGATION ALONG PMMA SAMPLES IN REDUCED GRAVITY ON REXUS 20 (UB-FIRE)

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To deal with the hazard of fire in human spaceflight there are many test procedures for ground testing facilities. On the basis of these test methods there is a broad understanding of different effects on flame propagation under normal gravity. To transfer these experimental results to reduced gravity conditions full-scale comparison experiments are needed. Within the REXUS/BEXUS program the "University of Bremen – Fire Safety Research Experiment" (UB-FIRE) was performed to investigate the concurrent flow flame propagation of five cylindrical PMMA rods. The samples were of identical diameter of 15 mm and of identical length of 100 mm but differ in terms of surface structure or core material. Besides the smooth full material reference sample there were two surface structured full material samples. The different surface structures were a vertically grooved and a vertically ripped PMMA rod. Two other samples featured a compound structure with an aluminium and a stainless steel core respectively. All samples were housed in individual combustion chambers to enable a constant concurrent flow of 18 cm/s along the sample's surfaces. This flow velocity is comparable to the air conditioning flow in human spaceflight systems like the ISS. By means of an infrared camera the leading edge of the pyrolysis front of each sample was observed. The camera was centrally mounted between the wind tunnels and alternately looked to the individual PMMA samples. The UB-FIRE experiment, flown on REXUS 20 in a reduced gravity environment (~0.079g), reveals a reduced pyrolysis propagation velocity up to a factor of 0.3 compared to ground-based experiments with an identical test setup (NASA standard test 1). Possible reasons for this behavior along with the detailed evaluation of each sample are discussed in this paper.

[A-066]

SECONDARY SCHOOL STUDENTS DESIGNING, TESTING AND FLYING EQUIPMENT TO STUDY THE QUALITY OF µGRAVITY ON DROP TOWER TESTS, PARABOLIC AND SUBORBITAL FLIGHTS

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Micro-gravity research is performed using either of different available platforms: drop towers, parabolic flight (with planes), suborbital flight (with sounding rockets) and orbital platforms, either crewed (the ISS) or not (satellites). Each platform has its pros and cons in terms of quality and duration of the µg phase, waiting time for a flight opportunity, price, limitations in mass/volume of the experiments, accessibility for the PI (Principal Investigator) during the flight and recoverability of the equipment.

In this paper all aspects of an Inertial Measurement Unit (IMU) experiment conducted by secondary school students will be discussed. This includes the design of the circuit using COTS components and development of the software (including successive improvements to accommodate flight provider confidentiality concerns and automatic selection of the appropriate measuring range to ensure the highest possible accuracy during each flight phase). Tests will also be discussed, including vibration tests on the shaker-table at the Royal Military School of Belgium, outgassing tests and thermal cycling. These latter tests were performed through the gracious cooperation of private companies.

The autonomous and self-starting circuit was then flown on the ZARM drop tower (Bremen, Germany), on a parabolic flight with Delft University of Technology's Cessna Citation II flying laboratory (Amsterdam, The Netherlands) and on a Maxus sounding rocket flight (Kiruna, Sweden).

The IMU measures the acceleration (and the magnetic field and rotations) on three axes. The 3D accelerometer's software automatically switches the measuring range between 2,4,8 and 16g. The magnetic field sensor can detect changes in the measurement setup's orientation in the drop tower and during the parabolic flights where no large external magnetic fields are present. Whether this holds true during the planned suborbital flight on Maxus remains to be determined.

A statistical analysis of the measurements will be presented, assessing the quality of the microgravity phase on each platform. Conclusions will be checked against literature to evaluate the quality of the setup and the processing/interpreting procedure.

Finally, the future of IMU measurements as a hands-on project for students is discussed: converting the present-day through-hole hardware to SMD will save space and make the electronics even more resilient to severe launch conditions, allowing the hardware to be flown as an educational payload on the first launch of the ICE-Cubes (International Commercial Experiment Cubes, i.e. experiments on the ISS's Columbus module) programme. Other - sought-for - flight opportunities include sounding rockets and (as a subsystem) cubesats.

[A-107]

LOTUS-D - LIGHT OPTICAL TRANSMISSION-EXPERIMENT OF UNIVERSITY STUDENTS

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LOTUS-D (Light Optical Transmission-Experiment of University Students – Data) was an experiment conducted by students of the TU Dresden, which should establish an optical communication link with a high-altitude-balloon.

Because of the high data rates which can be achieved by simultaneously reducing the required power, optical communication becomes increasingly important in aerospace engineering. The small volume and mass of the subsystems are further advantages compared to conventional radio communication systems. Due to these advantages, optical communication is used for more and more satellites. In addition to inter satellite communication, the communication between satellites and ground stations is also important, but is often interfered with by weather conditions. The LOTUS-D experiment should determine the influence of different atmospherical and technical conditions on an optical communication link from a ground station to a high-altitude-balloon.

By means of a modulated LED a predefined data sequence was send into the direction of the balloon gondola. A telescope was used to parallelize the LED light beam. The data sequence should have been received at the balloon gondola and compared with the original data sequence, to calculate a bit error rate. Depending on different weather conditions, modulating frequencies and the distance the bit error rate should have changed. The purpose of the experiment was to gather that data and to show a significant relation between the determining factors and the achieved bit error and data rates.

A pointing system which used a combination of GPS data and image recognition software was used to direct the telescope and therefore the LED light beam directly at the gondola.

The experiment was not able to establish an optical communication link between the ground station and the high-altitude-balloon, even though it worked under laboratory conditions. This talk is about the used experiment setup, the challenges that were faced and the reasons why the communication link could not be established.

[A-123]

SIGNON FROM BEXUS23

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The goal of SIGNON experiment was to use radio signals of opportunity, such as FM broadcast stations, DTTV stations and ADS-B signals transmitted by passing aircraft, to obtain navigation information during a stratospheric BEXUS flight. For this purpose software defined radio (SDR) receivers, tuned to these signals of opportunity, were used. Post-processing by correlation with equivalent data gathered by a small set of reference stations in known locations allows computing distances between transmitting stations and the balloon and, consequently, to obtain the balloon trajectory. Comparison with GPS data will provide an assessment on feasibility and accuracy for the use of these signals of opportunity for navigation at high altitude and for LEO satellites. The SIGNON experiment also tested the possibility of using DTTV signals for passive radar applications, measuring the signals scattered by the surrounding environment together with the direct signal from the transmitting stations.

[A-065]

SECONDARY SCHOOL STUDENTS DESIGNING, TESTING AND FLYING GEIGER COUNTER EQUIPMENT TO STUDY ATMOSPHERIC GAMMAS OVER EUROPE AND SVALBARD

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A single-tube Geiger counter datalogger was designed, built and flown on the Asgard-V educational balloon mission by a team of high-school students from Sint-Pieterscollege, Brussels, Belgium. It proved the suitability of the chosen MightyOhm Geiger counter module for such investigations by confirming both the Pfotzer-maximum around 20 kilometers and the altitude profile of atmospheric gammas as described in the literature.

In 2016, a three-tube Geiger counter assembly was designed to investigate the angular distribution of atmospheric gamma-radiation in an (unspecified) vertical plane using AND-gates as coincidence circuit. That experiment was largely successful, despite a battery failure on the descent leg of the flight. The hardware is currently being redesigned for an April 2017 reflight. The redesign aims to mitigate the Geiger tube voltage decrease in the 2016 hardware that occurred as a result of an Arduino compatibility modification on the original MightyOhm hardware. This upgraded hardware will be flown in conjunction with a magnetometer in order to complete the three-dimensional picture of angular distribution by determining the orientation of the setup in a horizontal plane. With the setup's 3 axes monitored (with respect to the Earth's magnetic field), a full 3D picture of angular distribution versus altitude should emerge. The results of this experiment and its precursor missions will be discussed, and the results compared to the literature.

Furthermore, in order to determine if atmospheric gamma ray production is latitude-dependent, a single tube Geiger counter datalogger was flown from the site of the Kjell Henriksen Observatory near Longyearbyen, Svalbard in September 2016. Differences in the altitude of the Pfotzer-maximum between Longyearbyen at 78°N and Brussels at 51°N, and in the altitude profile of gamma radiation intensity will be discussed. Clearly, a new balloon campaign over Longyearbyen is highly desirable to investigate the cause or causes of the observed differences at both moderate and arctic latitudes, and to extend the 3D profiling work being performed over Brussels to the Arctic, in order to gain clearer insight in the atmospheric gamma ray production processes at both latitudes.

Geiger counters however, are inherently limited particle detectors, in that they produce a signal when triggered by the passage of a gamma photon, but that the signal itself is independent of the photon's energy. Therefore work has started aiming at developing, over the coming years, a scintillation counter suitable for balloon flight, that would enable to determine the gamma-radiation's energy spectrum as a function of altitude.

[A-043]

ENGINEERING SATELLITE MODEL AS A TOOL FOR SATELLITE DESIGN, ITS EXPLOITATION AND STUDENT EDUCATION

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Traditionally, the engineering model is used for the designing of flight model, to test and debug hardware and software systems. In this paper we consider the development of an integrated engineering model (IEM) as a tool that (along with its traditional usage) is used together with the flight model, as well as during the education process. Architecture of the engineering model contains a common part (kernel), which is used to solve the problems of IEM, and additional hardware and software required to solve problems mentioned before.

Hardware and software tools of the kernel include basic service subsystems necessary for the satellite operation: power supply system, attitude determination and control system, scientific complex, communication system. Each of these subsystems is represented as a set of related hardware and software (engineering or mathematical models).

At the development phase engineering model is used to test all subsystems, flight software, satellite operation modes, to debug operation algorithms that will be used in the flight model. In this case, the additional tools are the simulators of external influences (sun exposure, influences for the scientific equipment, communication media simulators).

At the operation phase the engineering model is used for the testing of the developed software, debugging algorithms and operation modes before they are applied to real conditions on flight model or it can be used for testing in parallel with the flight model. Co-operation of the engineering and flight models in real time allows to control the correctness of the scientific data received, predict the behavior of the satellite, performing ground modeling, which is extremely important in case of emergency situations. In this case, the additional hardware and software (along with simulators) are specialized tools to obtain the original influences on the instruments on the base of the available scientific data to monitor the operation of service subsystems and payload.

During the educational process engineering model is used in the laboratory and practical training during the teaching of students in relevant areas. The main area is the information processing on board the satellite or within a ground segment, the hardware-software implementation of new technologies, data processing algorithms in order to increase the performance of satellite systems or ground segment infrastructure. The kernel of the system is supplemented with special software to analyze the satellite behavior and to assess the feasibility of new technologies and algorithms. Another challenge is teaching and training the operators of ground control stations in conditions close to real.

[A-169]

SLED FAILURE ANALYSIS:
HOW TO FAIL WHEN YOU ARE DESTINED TO SUCCEED

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The SLED experiment flew on REXUS 19 as a reflight of KTH predecessor ISAAC, REXUS 15. The experiment aimed to demonstrate autonomous tracking of a noncooperative entity by ejecting two units from the sounding rocket, one of which would track the other during free-fall. The secondary objective was to use these units to take IR measurements for a later spectroscopic analysis of the carbon dioxide composition of the mesosphere. Alas, neither objective was met and neither of the free-falling units was recovered after launch. The SLED team was left with no experimental data but the video recorded from within the rocket mounted unit. The results determined from this video include the status of the free-falling units upon ejection as well as an estimate of their direction and potential landing sites. An accompanying failure analysis conjectures at the most likely technical factors in the loss of the units.

A broader failure analysis examines the 18-month project and how a simple reflight became an exercise in crisis management. Reflections on a broad spectrum of topics provide insight into the SLED experiment and the critical factors in its failure. The challenges present in any team as well as those specific to a small team spread across four continents were explored. The need to discard heritage design, especially when the documentation to properly implement it is nonexistent, as a means of claiming ownership of and progressing the overall experiment was investigated. Both common and uncommon pitfalls and timesinks encountered by the team were enumerated. Nonetheless, the SLED team viewed the process as a rewarding one; a final look was given at how to find success in failure.

[A-057]

COMMAND FILTERED BACK-STEPPING INTEGRATED GUIDANCE AND CONTROL FOR HYPERSONIC GLIDER BASED ON EXTENDED STATE OBSERVER

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Hypersonic flight control is a challenging research area. This is due to the fact that the hypersonic flight dynamics is always associated with large nonlinearities, uncertainties and disturbances. The guidance and control system needs to deal with a large flight envelop, aerodynamics coefficients uncertainties, as well as flight states coupling. This paper presents an integrated approach for flight path angle (FPA) tracking in hypersonic glide phase. A back-stepping sliding mode controller based on extended state observer (ESO) is designed to cancel out the great aerodynamics coefficient uncertainties and unmatched time-varying disturbances in the longitudinal dynamics. In the design process, the command filters are implemented to solve the problem of 'explosion of complexity' in conventional back-stepping technique, and a Nussbaum function is applied to solve the problem of unknown direction of the saturated control input. The stability of the closed-loop system is proved by the Lyapunov theorem. The robustness and performance of the proposed control scheme is verified through numerical simulations.

[A-181]

STRATOSPHERIC BALLOON TRAJECTORY SIMULATIONS IN THE ANTARCTIC POLAR VORTEX FOR DUSTER FLIGTHS

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DUSTER (Dust from the Upper Stratosphere Tracking Experiment and Retrieval) is a balloon – born instrument designed to collect particles with sizes less than 30 microns in the upper stratosphere at altitudes of 30 – 40 km. DUSTER flown from Antarctica in February 2017. Because of the presence, in the period December – January, of the Antarctic Polar Vortex (PV), which generates a counterclockwise circulation with wind speed of 36 m/s, we had to evaluate the best launch opportunities simulating the possible balloon trajectories. We used the NOAA (National Oceanic and Atmospheric Administration) meteorological data from 1994 to 2015 to identify the trajectories maximizing the DUSTER time of flight over the southern polar region. We could identify the best trajectories as those occurring after the 10th of January. In addition, as for the DUSTER project it is pivotal to retrieve the instrument containing the collected samples, we used HYSPLIT (HYbrid Single – Particle Lagrangian Integrated Trajectory) program to project the balloon simulated trajectories on ground providing critical information for the recovery operations.

[A-032]

MINI-IRENE: DESIGN OF A CAPSULE WITH DEPLOYABLE HEAT SHIELD FOR A SOUNDING ROCKET FLIGHT EXPERIMENT

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MINI-IRENE is the the Flight Demonstrator (FD) of IRENE, a new-concept capsule with a variable geometry, originally conceived by ASI to widen the range of available platforms to retrieve payloads and/or data from low Earth orbit.

The FD is a capsule, equipped with a deployable heat shield aimed at a drastic reduction of the ballistic coefficient. This has beneficial effects on thermal and mechanical loads on the capsule during the re-entry and on the ground impact velocity, making a parachute not necessary.

The IRENE concept is based on a two stages deployment sequence. First the flexible thermal protection system (TPS) is extended by a set of radial poles, then the cloth is placed in tension and, most important, the hottest parts of the TPS are separated from both the structure of the capsule and from the deploying mechanisms.

This approach makes the present concept original if compared to other similar systems, based on inflatable or deployable systems. Due to the relatively low heat fluxes and taking advantage from the separation between TPS and structures, commercial materials and available technologies can be utilized both for the TPS and for the mechanisms.

The capsule shall be dropped by the payload stage of an VSB-30 Rocket after the burn out of the second stage, during the ascent, at 65 seconds from the lift off at an altitude close to 83km at a speed of about 1700 m/s. The fight would continue up to a 250km altitude. The landing is scheduled 860 seconds after the separation from the Launcher.

The paper, after a short description of the mission profile both for orbital and suborbital flights, focuses on the design of the mechanism that will deploy the umbrella and that will cope with the re-entry environment. A section of the paper will also describe the mechanism that will keep the system stowed for the launch and that will trigger the deployment.

An overview of the internal avionic and instrumentation systems is provided, including the architectural solutions conceived, aimed to increase the possibility of a successful mission.

[A-179]

THE PAYLOAD SERVICE SYSTEM OF KUNPENG-1B SOUNDING ROCKET"

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On April 27, 2016, Kunpeng-1B sounding rocket launched successfully by Chinese Academy of Sciences and the National Space Science Center in Danzhou,Hainan, China, which carried out a number of exploration of space science and technology experiments. In China, it is the first time to develop attitude control system for sounding rocket, which improves the comprehensive service capability of the payload service system. Also, the payload service system provides flight various status monitoring functions and an integrated design of integrated electronic. This paper introduces Kunpeng-1B sounding rocket payload platform system composition, function and the flight test.

The launching test of KUNPENG-1B
internet media.

For Example http://news.ifeng.com/a/20160427/48606776_0.shtml

[A-010]

DESIGN AND FLIGHT RESULTS OF A NON-POLLUTING COLD-SEPARATION MECHANISM FOR TY-3F SOUNDING ROCKET

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In Apr.2016, TY-3F sounding rocket was firstly launched successfully from the Hainan Sounding Rocket Launch Site, China. The rocket accomplished a series of actions during its flight, such as the separation of the head and the body, the separation of the bow cap and the fairing, which creating conditions for the scientific payloads of the rocket detecting space ionosphere. During the separation of the head and the body, the separation technology of cabin interface without pollution is made for avoiding detection sensor pollution, which contains "explosive bolts + compression springs + guide mechanism". This technology not only meets requirement of extreme clean environment for rocket detection sensor, but also offers no less than 2m/s of the velocity of separation of the head and the body. This paper introduces the working principle, design idea and the flight results of the non-polluting cold separation technology.

[A-027]

RECENT STEPS IN THE T-MINUS DART MOTOR DEVELOPMENT

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The T-Minus DART rocket system is specially designed for scientific research in the middle and upper atmosphere as successor of the unavailable Viper and Super Loki rockets previously used. The higher projected altitude performance of the DART compared to its predecessors, in combination with robust and durable active payloads, enables a completely new way of performing research.

To reach the desired altitude performance with a small and compact vehicle, it is essential that the solid propellant rocket motor, or Booster, is mass- and volume efficient. Next to that, safety and ease-of-use, and limited manufacturing cost are important requirements. The Booster design is developed in-house by T-Minus Engineering, and several innovative concepts are applied, such as use of light weight composite materials. Next to that, the Booster parameters, such as thrust and burn time are optimized towards a high vehicle performance, while keeping the vehicle acceleration and dimensions within constraints. This requires an optimization of the propellant properties, such as density, performance (characteristic exhaust velocity) and regression rate.

A test campaign was conducted to validate the most important concepts, materials and construction techniques. Next to that, a propellant development program is being conducted, wherein the formulation and production process are adjusted to the requirements. The results of this test campaign and development program show that the design is technically feasible. In the future development phases, the test scale will be gradually increased, leading to a number of full-scale static firings with which the design will be validated.

[A-139]

REXUS19 – LIME (LINK MADE EARLY) - INVESTIGATION OF AN ATTITUDE-DEPENDENT SATELLITE COMMUNICATION SCHEME

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Small satellites - such as CubeSats - impose strict mass and mechanical constraints on attitude control systems. Especially in the early phases of their mission, the communications could be difficult because of the slowly damped rotation of such satellites.

The LiME experiment proposes a dynamic scheme for the communication of CubeSats - based on current satellite attitude. To put in simple words: The satellites could use simple directional antennas and only transmit with high data rates while the main lobes are pointing towards a ground station. This scheme may help to improve data throughput and link stability in early mission phases as well as reducing power consumption, which is a critical factor for small satellites.

Furthermore it might be possible to realize satellite missions without any attitude control at all, while still maintaining high throughput communication.

For these purposes, a new ejection mechanism for a REXUS rocket was developed. The focus was on simplicity and a minimized spin of the ejected units. Four satellite models, in this case Free-Falling-Units (FFU) were ejected during the REXUS flight right after rocket de-spin at an altitude of about 65 km. The FFUs with a size of 70 x 50 x 15 mm were equipped with a LiPo-battery, a microcontroller and a radio-transmitter with a directional antenna. As a payload, each FFU carried a low-cost, small-footprint inertial measurement unit (IMU) for attitude determination. Each IMU consisted of a 3-axis MEMS-magnetometer, a MEMS-gyroscope and a sun-sensor consisting of 6 photo-diodes, one on each side of a FFU.

During the flight, every part of the IMU delivered data as planned. To gather all sensor data for further analysis, the raw data was sent to a ground station, no calculation was done onboard the FFUs.

The data fusion and attitude determination was done post-flight and correlated with the signal strength. It showed that the received signal strength fluctuation remained in close correlation with the attitude measurement of each FFU throughout the flight.

From the received and processed attitude data of the FFUs from the ejection altitude of approximately 65 km downwards till loss of signal were analyzed in detail. Exact IMU accuracy figures cannot be given, as time constraints made an exact calibration impossible before launch.

The gathered insights might be useful for future experiments in this area of research. Despite the positive findings obtained from the experiment, post-flight analysis showed that the scheme proposed by the LiME experiment does not seem to be overly aspirational for a CubeSat implementation. The time frame available for transmitting with a high data rate from the satellite is very small. In comparison to a more or less non-directional antenna system, the amount of data transmitted will be almost the same. It is also complicated to integrate directional antennas into a CubeSat form factor.

[A-140]

UB-SPACE ON REXUS 21: TEST DATA ACQUISITION FOR RELATIVE NAVIGATION WITH A CAMERA SYSTEM FOR A 360 DEGREE ROUND VIEW FROM A SOUNDING ROCKET

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Space debris is a growing challenge in space flight. Yet, no promising solution has been implemented to remove the amount of debris surrounding our planet. By using systems which are able to navigate autonomously, it is possible to detect and remove space debris, such as defective satellites. One important step within the removal procedure is the relative navigation during the final approach of the collecting vehicle to the target. To this day mainly visualisations are used to test camera-based relative navigation systems due to the lack of real images.

The UB-SPACE experiment on the REXUS 21 sounding rocket provides a freely accessible test data set of an uncooperative object in the space environment for camera-based relative navigation of space vehicles. The data shall in particular serve as an enhancement for the preparation of missions aiming at space debris removal, on-orbit servicing, formation flight, docking manoeuvres and other tasks where the approach to an uncooperative object in space is required.

A satellite-like Free Falling Unit (FFU) is ejected and observed from the rocket via 360 degree camera view. In addition, an IMU and sun sensors are used for attitude determination of the rocket. The acquired data enables a pose estimation of the FFU relative to the rocket by means of image processing.

This paper presents the experiment design and the acquired data with emphasis on the camera system which allows a 360 degree view from the sounding rocket with six cameras.

[A-022]

PROPERTIES OF A GAS-COMPRESSION BASED PRESSURE CONTROL SYSTEM FOR STRATOSPHERIC AIRSHIP

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With capability to realize long endurance resident at stratospheric height, stratospheric airships are expected to have various applications and mission scenarios in earth observation, communication, navigation, and scientific researches. In the past two decades, many airship programs have been proposed and conducted in contries like United States, Germany, Russia and China. Although a practical stratospheric airship is not available due to system or subsystem difficulties, great progresses have been verified or partly tested through airship ascend and descend experiemts. Now, phenomenons and issues in long endurance float phase, such as thermal effect, pressure variation, lift preserve and energy recycle, become main tasks for airship researchers.

Thermal problem is one of the key issues for a stratospheric airship keeping on station. Simulations and experiments results have demonstrated that time-varying characteristics of solar radiation, earth albedo, convection and infrared radiation lead to day-night swing of airship gas temperature as high as 50K or even more. For airships at pressure altitude, temperature variation could lead to the change of gas pressure over 1000 Pa, which is a significant chanllenge for stratospheric airship structure safety. Methods like improving envelop material property or venting lift gas are not proper for current airship program.

In this contribution, a gas-compress based pressure control system for airship which consists of pressure sensors, control model, pressurized envelope, a valve and a pump, is introduced. The pressurize envelope is made of high-strength ultra-light material. The principle of the system is that pressure variation due to temperature swings can be accommodated by compressing a margin of envelope lifting gas during the day and releasing it back to the envelope at night without any venting loss. Influence of pump and valve parameters, pressurized envelope parameters on system properties are investigated though a time-dependent model. Response and energy cost of three pressure control strategies are analyzed and discussed.

[A-166]

CORIOLIS MASS-FLOWMETER FOR AEROSTATIC GAS AMOUNT DETERMINATION IN ZERO PRESSURE STRATOSPHERIC BALLOONS

Jean-Baptiste Béhar,

French Space Agency - CNES.

The CNES ballooning community regularly operates zero pressure balloons in many countries around the world (recently in France, Sweden, Canada and soon, Australia in 2017).

An important operational flight parameter is the aerostatic gas mass injected into the balloon (currently helium and hydrogen in the study). Besides the lifting force, it determines mainly the ascent rate from which the adiabatic expansion depends directly. A too high ascent velocity in very cold air temperature profiles could result in a gas temperature drop which if too great, might induce brittleness of the envelope. A precise gas mass determination is therefore critical for performance as well as for mission safety.

The various gas supply tanks in various countries all have different characteristics with possible uncertainties with regard to their volumes. This makes the previously used gas mass determination method based on supply tank pressure measurements unreliable. That method also relied on tank temperature, another source of inaccuracy in the gas amount determination.

CNES has therefore prospected for alternative methods to reduce inaccuracies and also ease the operational procedures during balloon inflation process. Coriolis mass-flowmeters which have reached industrial maturity, offer the great advantage over other flowmeters to be able to directly measure the mass of the transferred fluid, and not calculating it from other parameters as other types of flowmeters would do. An industrial contractor has been therefore assigned to integrate this solution into the CNES operational setup. This new system has been tested in February 2016 and operationally used during Kiruna 2016 flights.

The poster will briefly explain the Coriolis flowmeter's principle and display the February 2016 performance tests' results. The expected incidence on zero pressure balloons' trajectories will also be discussed based on simulations ran on a balloon flight simulator software.

[A-058]

RESEARCH ON HIGH POWER STACKED BOOST CONVERTERS FOR THE POWER SUPPLY OF STRATOSPHERIC AIRSHIP

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With the rapid advance of airship technologies during the last decade, the stratospheric airship has attracted extensive attentions due to its unique features of long endurance, wide-area coverage, strong-survival ability, and low cost of manufacture and maintenance. In comparison with other types of low-altitude platforms, stratospheric airship is a more suitable platform for applications require long-range and long-duration capabilities, for example, the communication relay, remote sensing, high-resolution earth observation, environmental monitoring, etc,. Consequently, studies on stratospheric airship for various academic and practice purposes have been extensively conducted.

Among those researches, the study on how to improve the efficiency of the energy system so as to increase the flight duration has gained particular attention. This is because for stratospheric airship, its energy mainly relies on the solar-energy power supply system consists of a power supply converter, storage battery and a flexible thin-film solar-cell array amounted on the top surface of the airship. With the conventional power supply converter, the efficiency of the flexible thin-film solar cell array usually ranges between 5-10% of its maximum capacity, which is not high enough to meet the airship energy needs. Therefore, besides improving the efficiency of the solar cell array, many researchers are focusing on improve the efficiency of the power supply converter for the solar-cell power supply system.

One way to improve the converter efficiency is to apply Stacked Boost Converter (SBC) in the power supply system. Stacked Boost Converter is a new type of non-isolated boost converter, which is defined as a stacked branch on an isolated DC power converter consisting of a parallel input terminal and a serial output terminal. In compare with conventional DC power converter, the power transmit of the converter has not gone through the switching circuit, and the load is supplied directly by the superimposing branch. Therefore, it can achieve high efficiency during the power transmission. However, how to design a suitable high power SBC for the power supply system is still a major challenge in the airship industry.

To bridge the above knowledge gap, this paper aims to analysis the performance of the SBC in terms of current characteristics, input and output voltage relationship, transfer function of the main circuit, and magnetic deflection of the transformer. To achieve the goal of the study, a small-signal circuit model is designed and simulated through the Bode diagram. In addition, the system stability margin is examined based on the current inner ring and voltage out ring transfer functions.

[A-180]

THE INFLUENCE OF THE SOLAR CELLS ON THERMAL CHARACTERISTICS OF STRATOSPHERIC AIRSHIP

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The influence of the solar cells on the thermal characteristics of stratospheric airship are researched in this article. The mathematical models of heat transfer of airships and solar cells are established, including thermal balance equations, direct solar radiation, diffuse radiation from sky, reflected radiation from the Earth, infrared radiation heat transfer between the airship skin and the sky, infrared radiation heat transfer between the airship skin and the Earth, heat conduction between the solar cells and airship skin, and the convective heat transfer. And then, the multi-node model is adopted to discuss the temperature variations of stratospheric airship shin, solar cells and buoyancy gas. The multi-node model includes the solar cells,the airship's skin below the cells,other upper airship skin(upper airship skin except that below the cells),the down airship skin,the buoyancy gas. By numerical simulation, the temperature variations of the solar cells, airship skin and buoyancy gas during station keeping are presented. The effects of thermal resistance and conversion efficiency of the solar cells on the temperature variation of the solar cells, airship skin and buoyancy gas are especially analyzed. The research shows that,when the thermal resistance of the solar cells changes from 0.001m^2 K/W to 1m^2 K/W, the temperature of the solar cells increases from 309K to 405K, the daytime temperature of the buoyancy gas is reduced from 286K to 270K, and the temperature of the airship's skin the below the solar cells decreases from 309K to 267K; when the solar cell conversion efficiency is improved from 8% to 20%, the temperature of the solar cells drops from 360.6K to 344.6K, the daytime temperature of the buoyancy gas is reduced from 278K to 275K, and the temperature of the airship's skin below the solar cells decreases from 290K to 283K. The article can provide a guide for the design of the thermal control system of the airship skin.

LIFE AND PHYSICAL SCIENCES 1

WEDNESDAY 14 JUNE, MORNING SESSION – PART 1

CHAIR: M.EGLI

Plenary Invited Lecture

[A-175]

HUMAN CELLS IN MICROGRAVITY

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It is the dream of many people on Earth and countries to conquest Space. Important steps to realize this dream were parabolic flights, rocket flights, unmanned BION flights, or travels to space stations like the Mir in the past or actual the International Space Station (ISS). A long-term stay in space can cause various medical problems often observed in space travelers or animals returning from prolonged space missions. To investigate the different microgravity-related diseases, scientists examine the health of astronauts, cosmonauts or taikonauts or focus on the mechanisms of micro-gravity-dependent molecular and cellular changes.
In human cells, simulated and real microgravity influenced apoptosis, altered the cytoskeleton, and changed signal transduction, differentiation, growth behavior, cell adhesion and migration, cell cycle as well as cell adhesion. Short-term microgravity realized by parabolic flight maneuvers induced alterations of the cytoskeleton in various cell types (e.g. endothelial cells, chondrocytes, cancer cells). The cytoskeletal alterations were confirmed by the compact fluorescence microscope (FLUMIAS) for fast live-cell imaging of FTC-133 cancer cells under real microgravity (TX52 mission).

Several spaceflight missions with human cells (lymphocytes, endothelial cells, chondrocytes and cancer cells) revealed various changes in different biological processes, such as programmed cell death, growth, redifferentiation, adhesion and others.

One interesting result was cell growth of cancer cells in form of 3D aggregates (cartilage pieces, multicellular tumor spheroids) in space and under simulated microgravity. These spheroids can be used to examine multicellular responses in pharmacology, toxicology or radiation biology. Knowledge of the underlying mechanisms of microgravity-dependent changes is an important topic for improving Space medicine and developing new treatment strategies or countermeasures for humans in space.

[A-011]

FIRST INSIGHTS ON THE INFLUENCE OF ALTERED GRAVITY ON THE GENE EXPRESSION IN DAPHNIA MAGNA – A SOUNDING ROCKET EXPERIMENT (TEXUS 52)

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The waterflea *Daphnia* is a promising candidate for bioregenerative life support systems (BLSS), because of its essential role in the aquatic food web and its mode of reproduction. However, the effects of altered gravity on *Daphnia* have to be investigated, especially on the molecular level, to evaluate the suitability of *Daphnia* for BLSS in space. The experiment aboard the sounding rocket TEXUS 52 was designed to elucidate the influence of altered gravity conditions on gene expression in *Daphnia magna*. Three consecutive time points were chosen during the flight to compare the data with a 1g reference: Directly at the onset of microgravity (µg), to discriminate the effects of the launch and despin (hypergravity/ accelerations); at 180 s µg and at 360 s µg. We applied a microarray approach to identify genes involved in the response to different gravity conditions. In total, 755 of the significantly altered transcripts ($p < 0.05$) showed an at least 2-fold up- or down-regulation in expression. Gene Ontology (GO) annotation showed that the up-regulated transcripts are mainly related to stress response, protein and energy metabolism, transcription, electron transport and DNA/RNA metabolism. The down-regulated transcripts however are associated with cell organisation, biosynthesis, reproduction, the cuticle and the response to biotic/abiotic stimuli. By comparing the expressions patterns at the different time points, we have shown that the pattern of expression did not occur in a stereotypical manner. Some of the transcripts are regulated in an opposite manner by hypergravity/ accelerations and microgravity. This hints at a specific reaction to altered gravity conditions rather than being an overall stress response. Whether the differentially expressed transcripts are just an initial response or become manifest on the protein levels has to be further evaluated.

[A-003]

ELECTROPHYSIOLOGICAL MEASUREMENTS DURING A SOUNDING ROCKET FLIGHT, RESULTS FROM THE CEMIOS EXPERIMENT ON REXUS 20

Simon L. Wuest[1,2], ***Tobias Plüss***[1], ***Christoph Hardegger***[1], ***Benno Fleischli***[1], ***Aaron Kunz***[1], ***Mario Felder***[1], ***Lukas Rüdlinger***[1], ***Carlos Komotar***[1], ***Andreas Albisser***[1], ***Thomas Gisler***[1], ***Daniela Frauchiger***[2], ***Marcel Egli***[1]

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The mechanisms how cells detect external mechanical forces has not been fully clarified yet. Among other mechanisms, mechanosensitive ion channels are thought to be of central importance in transducing physical forces into biological responses. We are technically able to study the gating properties of mechanosensitive channels under various gravity conditions with our previously introduced "Ooclamp" device. The device applies an adapted patch clamp technique that has proven to be functional even during parabolic flights and during centrifugation up to 20 g. In the framework of the REXUS program, we have proposed to conduct electrophysiological measurements on-board a sounding rocket that provides a microgravity environment for up to 2 minutes. The aim of this experiment was to asses the feasibility to conduct electrophysiological experiments on-board a sounding rocket. This would allow to study possible adaptation processes of the mechanosensitive channels during the flight based on modified gating properties in microgravity.

In order to determine the transmembrane conductivity through the target mechanogated ion channel, an oocyte from the Xenopus laevis is captured in a silicone chip. A small aperture isolates electrically a patch of the cell membrane. This patch is in contact with a fluidic chip that allows fast exchange of extracellular medium. By using particular drugs, the ion channels of interest can be pharmaceutically isolated. The conductivity across the patch under the different treatment protocols is then measured using a voltage clamp circuit. The experimental flight module is designed as a stacked structure. Containers with liquids and gas pressure cartridges are mounted at the bottom. The six measuring chambers and medium containers are located above and can be inserted through a late access hatch. This enables a late loading of oocytes shortly before launch. The board computer, that controls the entire experiment, is mounted at the top.

The experiment flew with the REXUS 20 flight in March 2016. Unfortunately, the oocytes got ripped shortly after launch. A thorough analysis of the incidences leading to the loss of the cells indicates that the harsh lift-off conditions of the REXUS rockets in combination with the strong vibrations are likely to be the main reason.

[A-051]

ALTERATIONS OF THE CYTOSKELETON IN HUMAN CELLS IN SPACE PROVED BY LIFE-CELL IMAGING

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Microgravity induces changes in the cytoskeleton. This might have an impact on cells and organs of humans in space. Unfortunately, studies of cytoskeletal changes in microgravity reported so far are obligatorily based on the analysis of fixed cells exposed to microgravity during a parabolic flight campaign (PFC). The presented study focuses on the development of a compact fluorescence microscope (FLUMIAS) for fast live-cell imaging under real microgravity. It demonstrates the application of the instrument for on-board analysis of cytoskeletal changes in FTC-133 cancer cells expressing the Lifeact-GFP marker protein for the visualization of F-actin during the 24th DLR PFC and TEXUS 52 rocket mission. Although vibration is an inevitable part of parabolic flight maneuvers, we successfully for the first time report life-cell cytoskeleton imaging during microgravity, and gene expression analysis after the 31st parabola showing a clear up-regulation of cytoskeletal genes. Notably, during the rocket flight the FLUMIAS microscope reveals significant alterations of the cytoskeleton related to microgravity. Our findings clearly demonstrate the applicability of the FLUMIAS microscope for live-cell imaging during microgravity, rendering it an important technological advance in live-cell imaging when dissecting protein localization.

[A-001]

THYROID CANCER CELLS IN SPACE – RESULTS OF THE TEXUS 53 MISSION

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The thyroid carcinoma is the most common type of endocrine cancer. Even though good therapeutic results are achieved by surgery, chemotherapy or radioiodine therapy, not all types of thyroid cancer can be treated with similar effectiveness. Undifferentiated thyroid cancer cells have lost their ability of taking up iodine, which makes radioiodine therapy ineffective. Hence, new therapeutic targets have to be found to fight undifferentiated thyroid cancer.

Cancer cells were exposed to real microgravity (µ*g*) on parabolic flights, sounding rockets (TEXUS), unmanned space missions (Shenzhou-8), and the International Space Station (ISS). The resulting data revealed dramatic changes in cytoskeletal architecture, gene expression, cytokine secretion and the extracellular matrix. Short-term µ*g* of 22 s (and subsequently accumulated parabolas) during parabolic flights, revealed rearrangements in the actin cytoskeleton, accompanied by gene expression changes of up to 63 genes. In, addition we found rapid cytoskeletal changes within seconds of µ*g* by real-time live-cell fluorescent microscopy using the FLUMIAS microscope during the TEXUS 52 mission. In contrast to the short-term µ*g*-experiments, long duration culturing of thyroid cancer cells in space (5-10 days) during the Sino-German SIMBOX/Shenzhou-8 space mission revealed a three-dimensional growth pattern (multicellular spheroids) in concert with 2881 differentially expressed genes. Long duration µ*g* had the tendency to revert the cells to a less-aggressive phenotype.

It is still unknown, when exactly during µ*g*-exposure the transition from 2D to 3D growth occurs and at what time point the cells alter their differentiation. The exact mechanisms for these results are not known. Therefore, we investigated these cells after a stay of 6 minutes in µ*g* during the TEXUS 53 mission. Preliminary results show, that hyper-*g* during launch has little or no effect on the gene expression of selected genes involved in apoptosis and tumorigenesis. Samples which experienced µ*g*, on the other hand, presented a downregulation of these genes.

If we are able to determine the time point of the switch and its exact molecular mechanism, we might be able to find a new molecular target for future thyroid cancer therapies.

[A-090]

LIFE-CELL IMAGING OF F-ACTIN CHANGES INDUCED BY 6 MIN OF MICROGRAVITY ON A TEXUS SOUNDING ROCKET FLIGHT

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Many cell types form three-dimensional aggregates (MCS; multicellular spheroids), when they are cultured under microgravity. MCS often resemble the organ from which the cells have been derived. We have investigated human MCF-7 breast cancer cells after a 2 h-, 4 h-, 16 h-, 24 h- and 5d-exposure to a Random Positioning Machine (RPM) simulating microgravity. At 24 h small compact MCS were detectable, whereas after 5d many MCS were floating in the supernatant above the remaining adherent (AD) cells. The MCS resembled the ducts formed in vivo by human epithelial breast cells. qPCR analyses indicated that cytoskeletal genes were unaltered in short-term samples. IL8, VEGFA, and FLT1 were upregulated in 2 h/4 h AD-cultures. ACTB, TUBB, EZR, RDX, FN1, VEGFA, FLK1 Casp9, Casp3, PRKCA mRNAs were downregulated in 5d-MCS-samples. Furthermore, a whole-genome microarray analysis suggested that HMOX-1 and ICAM1 are activated under elevation of NFkB p65, when spheroids are formed.

To further elucidate the influence of microgravity and possibly early mechanisms of 3D spheroid formation, we are currently preparing a sounding rocket mission. MCF-7 cells stably transfected with a green fluorescing Lifeact-F-actin construct be used to perform life-cell imaging of changes in the actin cytoskeleton with the FLUMIAS microskope, which has already been successfully employed by us in a similar experiment with thyroid carcinoma cells, during 6 min of microgravity on TEXUS 54, which will be launched from ESRANGE, Sweden.

ASTROPHYSICS, ASTRONOMY AND COSMOLOGY 2

WEDNESDAY 14 JUNE, MORNING SESSION – PART 1

CHAIR: J-P. BERNARD

[A-170]

DESIGN AND 2016 FLIGHT PERFORMANCE OF POGO+ - A BALLOON-BORNE HARD X-RAY POLARIMETER

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PoGO+ is a balloon-borne telescope measuring the polarization of hard X-rays (~20-150 keV) from astronomical sources such as the Crab pulsar and nebula, and the Cygnus X-1 binary system. Using a 61-unit array of plastic scintillators surrounded by a segmented BGO anti-coincidence shield and a polyethylene neutron shield, the instrument is able to achieve a Minimum Detectable Polarization (MDP) of approximately 10% during a one-week duration flight. A custom attitude control system is used to align the instrument field-of-view of (~2° x ~2°) to the celestial source with an accuracy better than 0.1°. The system uses feedback from a differential GPS (~10 m baseline), a magnetometer (three-axis), an optical star tracker camera (co-aligned with the telescope axis) and a free-pointing sun tracker gimbal assembly (Position-Sensitive Device tracking brightest pixel of the sun). Each event triggered in the detector can be time-tagged to an absolute precision of about 100 ns, allowing pulsar light-curves to be reliably reconstructed. The two-tonne PoGO+ payload was launched from the SSC Esrange Space center on July 12^{th} 2016 and conducted a successful 7-day flight with altitudes exceeding 40 km, ending on Victoria Island, Canada. Here, the performance of the instrument and pointing system are reviewed, including remarks about risk mitigation in terms of communication reduncancy, thermal management and pointing system strategies.

[A-128]

PILOT OPTICS AND ITS IN FLIGHT PERFORMANCES

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PILOT is a balloon-borne experiment to measure the linear polarization of the faint interstellar diffuse dust emission in our Galaxy at wavelengths 240 µm (1.2THz) and 500 µm (545GHz) with an angular resolution of a few arcminutes. The first successful flight took place in September 2015 from Timmins, Ontario, Canada.

The PILOT instrument is designed to obtain wide-field maps, with instantaneous field of view of 1°x0.8°, and as a consequence, the image quality over all focal plane is important.

This paper describes its optical design, stray light blocking, optical alignment, and presents the ground tests results and in flight optical performances.

[A-077]

FORWARD TO AUTOMATIC FORECASTING OF RADIATION HAZARDS FROM SOLAR COSMIC RAYS FOR EXPERIMENTS ON LONG-LIVED BALLOONS, FOR AIRCRAFTS AND SPACECRAFTS

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In the last years became possible to have on-line through Internet one-minute cosmic ray (CR) data from many neutron monitors and muon telescopes (in high energy region) as well as from several spacecrafts (in very low energy region). To avoid damage of electronics and negative effects for people health is necessary in time forecast expected fluency of energetic particles and radiation hazards. It was shown by myself and colleagues that this possible to do by using the first 20-30 minutes of CR data on the basis of coupling functions, spectrographic method, and by solving inverse problem, and then calculate expected results on radiation hazards for many hours of Solar Energetic Particle (SEP) event. But all this must be made automatically, including the formation of corresponding alerts on the expected level of radiation hazard for different objects. We describe several automatically worked stages and obtain corresponding algorithms.

The **first's stage** works continue, collecting from Internet all available one minute data on CR variations (corrected on meteorological and geomagnetic effects). The **seconds stage** also works continue according to automatically working program "SEP-Start" - supposed, developed and checked in the Israel Cosmic Ray and Space Weather Centre. Using of this program on many CR stations and on satellites allowed to determine automatically the beginning of SEP event (it can be different at different stations caused to anisotropy at beginning of SEP). If the **seconds** stage gives positive result, starts to work automatically the **thirds stage** according to program "SEP-Coupling" – using method of coupling functions and spectrographic method for transformation obtained at different altitudes and cutoff rigidities data on CR intensity variations to the space and calculation CR energy spectrum and angle distribution out of the Earth's atmosphere and magnetosphere, directly in the interplanetary space near the Earth.

After obtaining results by **thirds stage** starts to work automatically the **fourths stage** according to program "SEP-Inverse Problem", and it is determined source function, time of ejection SEP into interplanetary space, and diffusion coefficient of propagation in dependence of SEP energy and distance from the Sun. After obtaining results by **fourths stage** starts to work automatically the **fifths stage** according to program "SEP-Direct Problem", and it is determined by found at **fourths stage** parameters the time variations of primary SEP in dependence of particles energy in interplanetary space near the Earth for many hours ahead, up to few days (on the basis of only 20-30 minutes of SEP beginning).

On the basis of information, obtained in the **fifths stage**, it is easy to calculate by known coupling functions and cutoff rigidities expected time variations of SEP intensity in atmosphere and in magnetosphere at different altitudes, and compare the beginning part with available observations and estimate the quality of forecasting (**sixths stage**, program "SEP-Forecasting"). If the forecasted radiation hazard is expected dangerous for different objects, will be immediately send corresponding Alerts (**sevenths stage**, program "SEP-Alerts"). By obtaining new data, forecasting Alerts became more and more exactly.

[A-105]

CHARACTERISATION AND PERFORMANCES OF THE PILOT INSTRUMENT

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PILOT is a balloon-borne astronomy experiment designed to study the polarization of dust emission in the diffuse interstellar medium in our Galaxy at wavelengths 240 µm and 550 µm with an angular resolution of a few arc-minute.

Several end to end tests were performed on the instrument before its first scientific flight that took place in September 2015 from Timmins, Ontario, Canada. The comportment of the instrument during the first flight and a second characterization campaign performed during the summer 2016 give us a better understanding of the PILOT instrument characteristics before its second scientific flight that is scheduled do be launched from Alice-Springs, Australia.

I will present the tests performed during characterisation campaigns and the performances of the instrument.

ATMOSPHERIC PHYSICS AND CHEMISTRY 3

WEDNESDAY 14 JUNE, MORNING SESSION – PART 2

CHAIR: F-J LÜBKEN

[A-091]

COMPARISON OF IN-SITU BALLOON-BORNE AND LIDAR MEASUREMENT OF CIRRUS CLOUDS

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Upper-tropospheric cold ice clouds play an important role in the radiative energy budget of the atmosphere. They can both have a cooling as well as a warming effect as they reflect part of the incoming short-wave radiation and absorb part of Earth's outgoing long-wave radiation, respectively. The net effect depends on the various cloud's macro- and microphysical properties, such as size and shape of ice particles.

A series of in-situ balloon-borne experiments conducted at Kiruna, Sweden (68°N) is targeting such upper-tropospheric, cold ice clouds. Compared to mid- or tropical latitudes, only few in-situ measurements exist at these Arctic latitudes. Experiments are launched from Esrange Space Center and collect ice particles with an in-situ imaging instrument, and measurements are complemented by a radiosonde ascending together with the instrument. One of the aims with these measurements is to improve satellite remote sensing of cold ice clouds. Cirrus clouds can be detected by lidar and cloud radar. However, they are often thin and are consequently better observed by lidar while they are invisible or very weak to the cloud radar. For these cases improved satellite retrieval methods will allow for better ice cloud determination by space-borne lidar only.

Therefore, on some of our in-situ measurement days ground-based lidar measurements have been carried out with two available lidar systems to accompany the balloon-borne measurements. One lidar system is the lidar at Esrange Space Center, approximately 500 m from the launch site on the balloon pad (operated by MISU, Stockholm University); the other is the lidar located about 29 km to the west of the launch pad (operated by the Swedish Institute of Space Physics, IRF). Here we present results from these lidar measurements and compare them to ice particle properties determined during the in-situ measurements. Depending on the shape of ice particles, the scattered light measured by lidar is more or less polarized. Consequently, we compare also the lidar depolarization ratios with the observed shapes.

[A-085]

SIMULTANEOUS IN SITU AND REMOTE OBSERVATIONS OF DUST IN THE POLAR SUMMER MESOSPHERE: AN OVERVIEW OF THE MAXIDUSTY CAMPAIGN

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The MAXIDUSTY campaign comprised two rocket payloads, launched from Andøya Space Center (69°17'N 16°01'E) on June 30 and July 8 2016, and simultaneous radar and lidar observations of the mesosphere with focus on the altitude region between 80 and 90 km. The sounding rocket payloads were equipped with several different types of dust instruments, including impact detectors, Faraday bucket detectors, a neutral mass spectrometer, electron density probes and a photometer. The first payload, MXD-1, was launched during PMSE and NLC conditions, and the MAARSY radar provided VHF measurements coincident with the rocket flight path. The ALOMAR RMR lidar provided NLC measurements during the first flight. The second payload was launched during similar conditions, but without lidar measurements. In this work, we present an overview of the MAXIDUSTY campaign with some general results. Some preliminary key results include a thorough analysis of the Faraday impact probe MUDD, which shows that it is possible to use the size distribution of fragments of colliding mesospheric ice particles as a proxy for the size distribution of meteoric smoke particles. Results from analysis of MUDD data also confirms that the volume filling factor of meteoric material inside mesospheric ice particles can be several percent. A comparison of PMSE structure and dust currents in the Faraday bucket DUSTY, show that there is no simple correlation between the two.

[A-144]

PROPERTIES OF ICE PARTICLES IN ARCTIC CIRRUS FROM BALLOON-BORNE IN-SITU MEASUREMENTS AT DIFFERENT METEOROLOGICAL CONDITIONS

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Shape, size and particle concentration are properties of cirrus-cloud ice particles, which mainly influence the radiative net effect of the cloud. These properties depend among other things on temperature and supersaturation and therefore the knowledge of them is very important for parameterizations and climate predictions. Especially, properties and radiative net effect of Arctic cirrus clouds are not well known.

Therefore, we are conducting balloon-borne in-situ measurements from ESRANGE (67° 53′ 38″ N, 21° 6′ 25″ E). Small particles down to a size of about 10µm can be measured and the shape of the ice particles can be determined. Additionally, an attached radiosonde provides temperature, humidity and height. The LTU imager samples cloud particles by collecting them on a tape coated with silicone oil and directly makes a photographic recording of the particles. Data analysis relies on post-image-processing. Because of the slow speed of the instrument shattering can be neglected.

All measurements were made in winter when the temperature in the clouds is very low. We evaluated data from eight measurement days. For those, the meteorological conditions reveal four occlusions, two cold fronts and two warm fronts. In most cases the wind was coming from Northwest connected with low pressure systems at the Norwegian coast. If the wind is coming from this direction Kiruna lies behind the Scandinavian mountains so mountain wave effects can occur. However, it is difficult to discern these effects clearly in the data. There is just one case when the wind came from Southeast from a warm front with its low pressure center over Finland. On this day bigger ice particles are prominent. Not only the origin of cirrus is an important fact but also the age of the cirrus. There is one day with a very high number concentration and all particles smaller than 50 µm. This may be caused by homogeneous freezing shortly before observation. This cirrus was formed by a low pressure system with center over Spitsbergen probably combined with Lee-wave clouds. For all days the main particle shapes were bullet rosettes, followed by columns and compact faceted polycrystals. Cirrus clouds by occlusions show a lower number concentration and bigger particle sizes than the cold and warm front cirrus. Properties of cirrus clouds may be distinctly different depending on meteorological conditions, however, more measurements are needed to confirm and strengthen these findings.

[A-059]

MEASURING WAVE GENERATED STRATOSPHERIC TURBULENCE WITH A LIGHTWEIGHT BALLOON-BORNE INSTRUMENT

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During a measurement campaign in January 2016 we have observed an extraordinary case of layered turbulence generation. To characterise this turbulence, we have measured the energy dissipation rate with a lightweight version of our balloon-borne instrument LITOS (Leibniz-Institute Turbulence Observations in the Stratosphere). This instrument is capable of resolving the Kolmogorov microscale of turbulence. It weighs below 5 kg and therefore combines a precise turbulence measurement with the capability of being launched from every radiosonde station. This new version of the LITOS instrument obtains information on the meteorological background by a radiosonde. When interfering with strong gravity wave motions any radiosonde-like instrument will show an ambiguity of horizontal and vertical wave parameter. This has been resolved using WRF simulations at 800 m resolution and ECMWF fields for larger scales.

Earlier measurements with the LITOS instrument have revealed some turbulent activity across the whole flightpath. In contrast, on 29 January we find pronounced maxima in the altitude range of 24 to 32 km. Comparing with the WRF simulations, we see that these turbulent layers coincide with a distinct phase of a mountain wave. Furthermore, the propagation of the mountain wave and the strength of the turbulent layers relate to the background wind conditions. Therefore, our high resolution balloon-borne measurements and their combination with 3d simulations provide a unique opportunity for further understanding of turbulence generation by gravity wave breakdown processes.

[A-108]

PROSPECTS FOR IMPROVED INFRASOUND DETECTION FROM BALLOON-BORNE PLATFORMS

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Infrasound waves are generally defined as acoustic waves with frequencies below 20 Hz, the nominal limit of human hearing. Infrasound waves have the useful property that they can travel vast distances with relatively little attenuation. The Comprehensive Test Ban Treaty Organization (CTBTO) monitors a global network of 45 ground stations equipped with infrasound instrumentation. Several of these stations detected the 15-FEB-2013 Chelybinsk bolide; some stations recorded infrasound waves that circumnavigated the globe, a day after the bolide impact.

There are two reasons to think that a balloon-borne infrasound microphone would outperform one on the ground. First, a free-floating listening station would have virtually no wind noise, which is one of the main noise sources for ground-based stations. Second, the temperature profile of the Earth's atmosphere leads to stratospheric ducts between altitudes at which there are local temperature maxima. Infrasound energy can propoagate within these waveguides without the customary $1/r^2$ attenuation.

To test the efficacy of infrasound sensors in the stratosphere, we conducted an experiment to compare balloon-borne and ground-based sensors. On 28-SEP-2016, we flew two sets of infrasound sensors on a NASA high altitude balloon, launched from Ft Sumner, NM. During that flight, we arranged for three 3000-lb explosions to be set off from Socorro, NM, at noon, 2 PM and 4:30 PM (MDT). All three explosions were detected on the balloon, at line-of-distances ranging from 335 km to 395 km. The first explosion clearly shows three distinct N-shaped waveforms, arriving over a 25-s interval. The background noise level on the balloon was extremely low, such that waveforms with 0.06 Pa amplitudes could be characterized with a SNR of ~20. A second solar balloon was launched near Ft Sumner and detected the second explosion from a height of 15 km. Not all ground stations detected the explosions. We will present propagation models in the context of the signals reported from the balloons and the ground stations.

[A-165]

25 YEARS OF ATMOSPHERIC SCIENCE WITH MIPAS-B

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MIPAS-B (Michelson Interferometer for Passive Atmospheric Sounding – Balloon) is a balloon-borne limb-emission sounder for atmospheric research. The heart of the instrument is a Fourier spectrometer that covers the mid-infrared spectral range (4 to 14 µm) and operates at a temperature of approximately 215 K. Essential for this application is the sophisticated line of sight stabilization system, which is based on an inertial navigation system and supplemented with a star camera reference system. The major scientific benefit of the instrument is the simultaneous detection of complete trace gas families in the stratosphere, without restrictions concerning time of the day and viewing directions.

MIPAS-B is an in-house development that was started in the mid-eighties. It initially served as proof of concept for the proposed space borne MIPAS instrument that was later realized and operated on the ESA satellite ENVISAT between 2003 and 2013. But actually it soon became obvious that operation from stratospheric balloons offered a number of benefits to address dedicated scientific questions in an optimal way. MIPAS-B was operated in two versions during 24 flights at tropical, mid-latitudinal and arctic latitudes between 1989 and 2014 covering the 'golden era' of ozone loss research and the full operational period of ENVISAT.

This paper describes briefly specifications, design considerations, technological upgrades and the characterization of the instrument. The evolution in the skills of its remote operation from ground and of data analysis in the course of the 25 years are outlined. Scientific applications in the field of atmospheric research, spectroscopy and satellite validation are highlighted.

LIFE AND PHYSICAL SCIENCES 2

WEDNESDAY 14 JUNE, MORNING SESSION – PART 2

CHAIR: A.VERGA

[A-080]

FOKUS II – A VACUUM COMPATIBLE DUAL FREQUENCY COMB SYSTEM

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The ongoing development of optical frequency combs since its invention in the late 1990s lead to a revolution in precision metrology and optical synthesis. The technology is now well established in laboratories across the planet, but not only Earth-based research can profit from this tool. Promising concepts for space-based applications already exist in various fields, for example as a remote sensing tool in LIDAR (LIght Detection and Ranging) instruments, as high precision clock in navigation satellites, or for intrasatellite ranging. Nevertheless, a lack of compact and robust combs prevented the actual use in space so far. For this purpose a first prototype comb FOKUS I (Ger.: Faser-optischer Kammgenerator unter Schwerelosigkeit) was developed by the Max Planck Institute for Quantum Optics (MPQ) and Menlo Systems GmbH in cooperation with the German Aerospace Center (DLR) and launched on a TEXUS sounding rocket in April 2015 and January 2016.

The succeeding generation, FOKUS II, is currently under development and scheduled to be part of the TEXUS 54/55 campaign in late 2017. The system will further miniaturize the technology and aims to reduce key system parameters, namely power consumption, mass and volume by a factor of two to 50 W, 15 kg and 8 liters, respectively. Compared to its single comb predecessor, FOKUS II will also feature two frequency combs in order to create an autonomous system, capable of rapidly determining (ms scale) the frequency of an unknown continuous wave laser, e.g. determining the absolute comb mode number generating the beat with the device under test. This will be demonstrated on the TX 54 flight, by performing precision spectroscopy on an Iodine referenced external cavity diode laser, developed by the Humoldt University Berlin. Additionally, to further raise the technology readiness level, the technical limitations of the first prototype will be eliminated and moreover, the device will be fully vacuum compatible and operable without a pressurized dome during flight.

We will report on our system design, the environmental testing campaign as well as give a brief outlook on the upcoming sounding rocket flight and the scientific research goals.

[A-037]

DREAM – DRILLING EXPERIMENT FOR ASTEROID MINING

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In present days space operations are not only measured in scientific and technical goals. Economical aims gain recently bigger influence in space industry.

One of the greatest opportunities for mankind space expansion is the asteroid mining. Although there is certainly a big gap between current human or robotic spaceflight operations and running space mining industry, scientists and engineers already work hard on simulating asteroid conditions for excavating ore such as platinum or nickel.

The DREAM project (DRilling Experiment for Asteroid Mining) takes part in European international programme, led by European and German Space Agencies and Swedish National Space Board, called REXUS (Rocket Experiment for University Students). Organizers allow participants to take part in suborbital flight up to almost 100 kilometers on-board the sounding rocket launched from Esrange Space Center in Kiruna, Sweden. The DREAM project is scheduled to be launched in March 2017.

The experiments' scientific goal is to measure the conditions and aspects of drilling in space environment, especially to measure the output distribution and condition of output after excavation. These parameters will be measured by the vision system equipment in measurement chamber during flight and the rest will be the result of on-ground analysis. Such process has never been studied in the space missions before.

Most challenging part of designing space equipment is to ensure that it will survive both harsh conditions of delivery and work in the outer space. The technical goal of the experiment is to design the robust equipment able to perform drilling operations in space.

One of the most innovative parts of the experiment is the measurement chamber for drilling. The chamber will have the functionality to capture the drilled outcome saving its distribution vector for the post-flight data analysis. With the use of the laster triangulation techniques and the fast camera acquisition the DREAM project will be able to provide information about the 3D position of almost every rock fragment excavated during the drilling procedures in the reduced gravity.

[A-158]

SIZE MATTERS – MAXUS 9 SOUNDING ROCKET MISSION

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Since more than 25 years MAXUS missions are performed jointly by Airbus and SSC on behalf of ESA. MAXUS rockets are the largest civil rockets in Europe and launched from Esrange, carrying more than 800 kg of equipment to an altitude of up to 750 km. The payload consists of scientific or technological experiments along with the required service and rocket systems. During the microgravity period of up to 13 minutes scientists and engineers perform a large variety of experiments which are monitored and controlled in real-time.

MAXUS 9 is scheduled for launch in April 2017. This time four scientific experiments are onboard which were developed by Airbus and SSC and in addition a technological experiment which was provided by ESA.

This paper will focus on the challenges during the preparation phase of such a complex microgravity mission and give insight into the multitude of possibilities that are offered during sounding rocket flights. In addition, an overview of the complete MAXUS rocket system characteristics will be given, highlighting how the specific safety requirements, related to launching a rocket of this class from Esrange, are met.

[A-125]

XRMON-SOL MICROGRAVITY EXPERIMENT MODULE ON MASER 13

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XRMON-SOL microgravity experiment observes spatially isothermal equiaxed solidification of an Al–Cu alloy in microgravity on board the MASER 13 sounding rocket, launched in December 2015. It is the first time that isothermal equiaxed solidification of a metallic alloy has been observed in situ in space, providing unique benchmark experimental data.

The experiment used a newly developed isothermal solidification furnace in the re-used framework of the MASER 12 experiment XRMON-GF. A grain-refined Al–20 wt%Cu sample was fully melted and solidified during 360 s of microgravity and the solidification sequence was recorded using time-resolved X-radiography. Equiaxed nucleation, dendritic growth, solutal impingement, and eutectic transformation were thus observed in a gravity-free environment.

This experiment is being led by the School of Mechanical & Materials Engineering at University College Dublin. The scientific study has been published on Journal of Crystal Growth in September, 2016.

This presentation will outline the technology development of the XRMON-SOL experiment module and the flight control of the experiment.

[A-152]

MASER 13 SOUNDING ROCKET MISSION – WORTH WAITING FOR

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Five experiments on a MASER sounding rocket were launched from Esrange Space Center in northern Sweden on a dark and misty polar night "morning" on 1 December 2015.

The ESA-financed MASER-13 rocket with its 270 kg scientific experiment mass was propelled to an apogee of 260 km, providing six minutes of weightlessness. Once the payload had been separated from the motor – less than a minute after take-off – the mission begun for the scientists, having waited long for the launch. They now had six minutes to run their experiments and collect experiment data during the ballistic free fall.

MASER-13 carried five experiments of different disciplines; XRMON-SOL of Dr. David Browne, from Dublin's university which studied isothermal equiaxed solidification of an Al–Cu alloy melted in a small high-temperature furnace, A live on-board X-ray camera captured the beautiful dendric growth for analysis. MASER-13 also featured two biology experiments, SPARC and GRAMAT of Prof. K. Palme Univ. of Freiburg studying root growth, using A. Thaliana (thale cress). There was also fluid dynamics CHYPIE-MARCHE experiment of Dr. A de Witt et al. with the objective to observe hydrodynamic instabilities generated by chemical reactions, and finally the MEDI-CETSOL experiment of Pr. L Sturz et al., which the aimed at investigating formation of equiaxed crystals in liquid solutions.

The launch campaign itself was a thrill. As icy weather conditions had for several days prevented any attempt of recovery by helicopters, and therefore grounded the rocket, a team of snow mobiles had been sent out to the impact area for early recovery of the biological samples, quite outside the nominal recovery scenario. Finally, the MASER 13 payload landed on the first day of December in a mist-covered flat, high-ground area, only 5 km off a semi-major snow mobile track and in 17 km reachable distance of the snow mobile team. The biological samples, placed in a dedicated temperature isolated battery-heated box, could less than eleven hours after launch be returned in excellent condition to the Science Team

The MASER system accommodates 4 to 5 dedicated 17" experiment modules of high complexity and offers real-time digital television monitoring as well as control capabilities during the flight of the scientific experiments. MASER programme has provided thirteen successful MASER flights of 6-8 minutes of microgravity. Introduced with the Cryofenix mission in 2015 using the MASER bus, low gravity levels can be provided to experiments.

The paper reports on the main features of the MASER-13 sounding rocket mission and some of the achieved results during its missions as well as on the MASER programme.

[A-106]

FLUMIAS AND PERWAVES: TWO EXCITING NEW EXPERIMENT MODULES

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With FLUMIAS (**Flu**orescence-**Mi**croscopic **A**nalysis Unit for **S**pace Applications) and PERWAVES (**Pe**rcolating **R**eactive **Waves** in Particulate Suspensions) two quite complex experiment modules have recently been developed.

FLUMIAS, funded by the German Space Agency DLR and built by Airbus DS in cooperation with FEI Munich, was already successfully flown on TEXUS 52 in spring 2015 and is scheduled for a reflight with some modifications on TEXUS 54 in autumn 2017. Besides TEXUS the FLUMIAS experiment has also been part of the 24th (spring 2014) and 29th (autumn 2016) DLR parabolic flight campaigns. Equipped with a confocal fluorescence microscope the FLUMIAS experiment belongs to the field of biological sciences and enables reseachers to investigate living cells under micro-gravity conditions with high axial and spatial resolution. Besides human cells also plant cells have already been used as sample material. Due to the successful implementation of FLUMIAS on TEXUS an ISS version of FLUMIAS is currently under development.

The PERWAVES experiment funded by the European Space Agency ESA and built by Airbus DS is scheduled for the MAXUS 9 flight in spring 2017. Scope of the PERWAVES experiment is the analysis of the discrete particle combustion without disturbing gravitational effects. Small iron particles with sizes around 25 µm are used as combustible material. Serveral optical diagnostic tools have been implemented into the experiment to capture as much information as possible about the percolating reactive waves. Due to the complex nature of the discrete particle combustion several drop tower campaigns for parameter optimization have been conducted during the development process.

[A-160]

ROOTS IN SPACE –THE BIM-3 MICROGRAVITY EXPERIMENT MODULE

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The BIM-3 (Biology In Microgravity) experiment module is designed for biological experiments under contract from the European Space Agency (ESA) and flew on MASER 13 sounding rocket in December 2015. The experiment module is designed and manufactured by Swedish Space Corporation and RUAG Space Nyon,. BIM-3 experiment module is a reflight (however with modifications to meet the specific requirements of the experiments) of BIM-2 flown in spring 2012, which in turn was based on the design of the BIM experiment module flown on of MASER 10 in 2005.

BIM-3 experiment module contained 2 plant biology experiments SPARC and GRAMAT "Gravity perception/signal transduction pathways & auxin-transporting proteins" of Prof. K. Palme Univ. of Freiburg. Both experiments study the root growth mechanisms of the plant A. Thaliana.

The BIM-3 experiments are performed in 48 experiment units. Plants, cultivated in a day-night regime, grow in microgravity conditions, and also in a 1 g reference centrifuge on-board the module, and are exposed to a fixative just before end of microgravity conditions. There is also a reference cultivation on-ground. The experiment units are prepared few hours before launch and are integrated in late access unit systems. The flight system is installed in the module via a hatch. The ground system with the reference experiment units is placed in an incubator.

This paper will focus on the technical design of the experiments, the overall module design and the specific launch and recovery requirements.

Technology and Infrastructures for Balloons 1

Wednesday 14 June, Morning session – part 2

Chair: M.Abrahamsson

[A-130]

BOOSTER – BallOOn for Science and Technology from Esrange

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BOOSTER is a balloon flight proposed to fly in the fall of 2018 with three balloons: one main balloon and two smaller ones in the stratosphere with four different experiments for two days. BOOSTER will give insight in atmospheric and magnetospheric physics and also serve as a technology demonstrator for future planetary missions.

This is the first time SSC/Esrange will fly three balloons in a formation with four infrasound microphones. In order to conduct triangulation, two of the microphones will be located on each of the smaller balloons and the other two will fly on the main balloon, separated by a 100 m wire extended below the gondola. The experiment is a development from the BEXUS program EXIST. Infrasound can be used to analyze e.g. volcanic eruptions, meteors and severe weather. Northern Europe contains a dense network of ground-based sensors and a wide range of industrial infrasound sources useful as ground-truth reference events.

ESA's mission to Jupiter (JUICE) will carry the Particle Environment Package (built under the lead of IRF Kiruna), to investigate the plasma and neutral gas environment. However, Jupiter possesses powerful radiation belts that can cause complications hence testing of electronics and particle detectors against this powerful background radiation is imperative for science success at Jupiter. The RATEX-J experiment on BOOSTER main balloon will use the secondary particles generated from cosmic ray background radiation at 30 km to characterize the response of different detector types used in PEP.

An all-sky camera will be located on top of the main balloon (pointing at zenith) for studying spatial and temporal dynamics of polar mesospheric clouds (PMCs) in order to estimate the spatial sizes and temporal variability of PMCs at polar latitudes. The study will also investigate the wave activity in the middle atmosphere by using information on the wave spectrum retrieved from images of PMCs, which are the highest clouds in the Earth's atmosphere observed around the summer mesopause at 80-85 km. The basic physics of PMC formation is rather well understood at present. However unanswered questions include those concerning secular trends in PMC characteristics, the relationship between PMCs and solar activity, PMC field actual sizes, their spatial and temporal dynamics and others which need to be investigated.

A Laser Heterodyne Spectrometer (LHS), designed and built by MIPT (Moscow Institute of Physics and Technology), will be mounted in a gimbal construction on the main balloon's gondola, allowing to track the sun independent of the gondola movements. The spectrometer detects climate relevant greenhouse gases CO_2 and CH_4 in the near-infrared region. This project is a feasibility study for LHS, partly to test the gimbal solution tracking the sun and the instrumental performance under near-space conditions. Given a positive result from this flight the rather new concept allows for future piggy-back flights due to the instrument's low weight and power consumption.

[A-143]

DEVELOPMENT OF ULTRA-SENSITIVE PORTABLE 3D MAGNETOMETER BASED ON DIAMOND NV-CENTERS FOR OSCAR (BEXUS 23)

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Ultra high sensitive measurements of the magnetic field have a wide range of applications, such as navigation, biomedical appliations, geology, mining, solar wind measurements and other space applications. The quantum measurement techniques open new field of applications providing unmatched sensitivity, however most of these techniques can only be used at cryogenic temperature and do not allow the development of portable devices.

A possible solution for a highly sensitive and widely employable quantum magnetic field sensor exploits point defects in a diamond lattice, namely Nitrogen-Vacancies (NV) centers. This diamond magnetometer is based on single electron spin of the NV centre as a massless sensor. The technique works on the principle of the Zeeman splitting between the NV centers electronic spin energy levels, proportional to the external magnetic field. The optical readout is performed by detecting the photoluminescence emitted by spin conserving transitions from a NV centre. The great advantages of this kind of sensor are the aforementioned high sensitivity, which in theory can reach 50 fT/√Hz, and the intrinsic stability of diamond in harsh environments (temperatures between ~0 and 800K, extremely high and low pressure, and high energy radiation).

The idea behind the OSCAR (Optical Sensors based on CARbon materials) project was to test the feasability of carbon-based devices, such as the cited magnetometer, in an aerospace environment during a stratospheric balloon flight. With this scope in mind, we developped a vector diamond-based magnetometer which probes the projection of the magnetic field along the four orientations of the NV centers in the diamond crystal. The diamond magnetometer serves as a three-dimensional compass, providing information about rotation, pitch, and roll. The complete device was designed to satisfy the requirements of low mass, low power consumption, and high reliability imposed by the space industry for the launch on the BEXUS balloon.

The presentation will outline the device structure, together with the strategies adopted to overcome the initial setbacks (interference, signal acquisition and system calibration), and the first results on diamond-sensed magnetic field in the stratosphere.

Ongoing work is focused on a fully electrical readout method, potentially leading towards further miniaturization and enhanced sensitivity of the device.

[A-019]

TDP-3 VANGUARD: VERIFICATION OF A NEW COMMUNICATION SYSTEM FOR CUBESATS ON BEXUS 22

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CubeSats are evolving from simple, low-cost satellites built solely for education purposes to ever more powerful platforms capable of supporting scientific experiments. Among the technologies required for the operation of scientific instruments are communication systems that can transmit all relevant data to its operators. We have developed two such systems for the MOVE-II satellite, a single-unit CubeSat being built at the Technical University of Munich (TUM). Slated for launch in late 2017, MOVE-II shall demonstrate several new technologies supporting the operation of scientific instruments in successive missions.

We conducted the TDP-3 (Technology Demonstrator Platform 3) *Vanguard* experiment aboard the BEXUS 22 stratospheric balloon to verify the correct operation of the communication systems in a near-space environment and at large distances between the transceivers and the receiving ground station. We tested two transceivers: one operating in the VHF band at 144.5 MHz with a bandwith of 25 kHz and one operating in the S band at 2.323 GHz with a bandwidth of 2 MHz. Both systems use FPGA-based architectures to achieve a flexibility comparable to a software-defined radio, supporting high data rates, modern channel encoding, and error correction algorithms. We used a commercial software-defined-radio station for receiving the VHF signals and the DLR MORABA telemetry station at Esrange Space Center to receive the S-band transmission.

We present data of the successful operation of the TDP-3 *Vanguard* experiment during the BEXUS 22/23 campaign. Both communication links were operational during the whole ascending and floating phase. The signals were lost about half an hour after cut-off at elevations of 2 degrees (VHF) and 0.1 degrees (S band). We also present data to show our systems’ compatability with CCSDS standards and their compliance with international radio regulations.

[A-079]

DESIGN, VERIFICATION AND VALIDATION OF A SIMULATION TOOL FOR HIGH-ALTITUDE, ZERO PRESSURE BALLOON TRAJECTORY FORECAST

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High-altitude, zero pressure balloons have played a vital role in numerous scientific discoveries. They provide a platform for environment research, monitoring the ozone layer, and testing future space instruments and space vehicles. Significant discoveries in the atmospheric and space sciences have been made using balloon-borne instruments.

Balloons work on the principle of buoyancy, and once deployed in the atmosphere, they are subjected to various dynamical and thermal forces. These forces make the balloon flight complex, as they are dependent upon various atmospheric parameters, such as pressure, temperature, solar radiation, planetary surface infrared radiation, atmospheric convection, lifting gas temperature change, etc., which are not easy to estimate. Further, after few hours of deployment, a high-altitude balloon reaches equilibrium buoyancy and floats in the direction of the winds, making the balloon flight uncertain as winds are not known to a great extent at such altitudes. As a result, balloon trajectory forecast poses several challenging problems since the subject is both complex and multidisciplinary. Consequently, balloon mission preparation requires an accurate and reliable prediction methodology for both weather and trajectory, in order to accomplish the mission successfully.

In this paper, the authors describe the software design of a tool that can forecast the trajectories of high-altitude, zero pressure balloons using radiative, convective, and heat transfer models, and also taking into account the actual design and shape of the balloon for both ascent and float durations. The balloon trajectory profile is parameterized based on the planetary environment, mass properties, volume characteristics, thermal load, pressure variation, and other properties, along with the features such as ballasting and venting. In addition, meteorological information, i.e., the atmospheric and wind data from European Centre for Medium Range Weather Forecast (ECMWF), is used for characterizing the forecast errors, leading to a methodology for the computation of dispersion regions around the predicted balloon trajectories. The designed software decouples the environment and balloon trajectory models to allow a given balloon design to be flown within any number of environment models with different levels of fidelity. The software provides integrated vertical and horizontal trajectory modeling and extensible application architecture to allow for different balloon designs and new environments. The designed software is verified by comparing its features and user interface with those of the two state-of-the-art tools that are not commercially available. Validation of the software is done by using the trajectory data from some recent and past high-altitude, zero pressure balloon flights from Esrange Space Centre of Swedish Space Corporation (SSC).

[A-014]

THERMAL ANALYSIS OF COMPONENTS FOR STRATOSPHERIC EXPERIMENTS USING FINITE ELEMENT MODEL UPDATING OF THE BEXUS20:HACORD MISSION

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In general, it is difficult to analyse equipment for space applicability due to the fact that realistic tests on Earth are technically difficult and expensive. To prove the reliability of space systems, a combination of numerical analysis and expensive pre-flight tests is used. However, this paper discusses a new methodology in which a combination is made of low-budget ground tests with a newly developed finite element model updating technique which can deliver a time efficient added value or alternative to the expensive and time-consuming pre-flight tests during thermal analysis. In addition, this contribution shows the influence of several design parameters on the accuracy of thermal simulations for space applications and discusses how this accuracy can be optimised. The experimental data is compared with an updated and a regular numerical simulation of the performed experiment.

The objective of this contribution is to predict the thermal insulation and heat distribution in the HACORD (High Altitude Cosmic Ray Detector) balloon experiment of the BEXUS20 mission while being exposed to stratospheric conditions using two ground tests which are easy to perform: an actual long duration stratospheric flight and numerical simulations. The flight is made within the REXUS/BEXUS programme using a balloon with a floating time of more than two hours at an altitude of 28.2 km.

To ensure accurate numerical simulations a finite element updating technique is used for non-destructive evaluation. The technique is adapted for more general 3 dimensional thermal problems. The prediction results are validated using the real experimental data retrieved by thermal sensors during flight. The goal of this contribution is to validate if it is possible to better predict experimental device behaviour in space by using a straightforward thermal load and freezer experiment, performed in atmospheric conditions as input for an FE model updating routine. The described methodology can be used to accelerate the design process of atmospheric balloon experiments and helps to improve the design process of future spacecraft.

[A-006]

AN EXPERIMENTAL INVESTIGATION INTO THE THERMAL PERFORMANCE OF SPHERE BALLOON

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Scientific balloons have wide applications in the fields of scientific observations and development of space technology. The scientific balloons could flight to its design altitude by itself or be transported by sounding rockets into higher atmosphere. The flight characteristics of balloon are governed by complex relationships of fluid dynamics and thermodynamics. A comprehensive and accurate understanding of the thermal performance of the balloon is a prerequisite for balloon designing, constructing and mission planning.

The present paper reports on efforts to investigate the thermal performance of sphere balloon through ground experiment.

Sphere is one of the most common shapes of balloon, the ground experiment could provide vivid insight into the thermal performance of the sphere like shapes of balloons. And the experimental data could be used to improve the thermal simulation model for other shapes of balloons and airships, as the heat transfer calculation for the sphere has the highest accuracy.

In the experiment, thermocouples were placed on various locations of the balloon envelope and inside of the balloon to provide temperature distribution information of the balloon. Four sphere balloons that made up with different materials were used in the experiment to investigate the influence of the radiative properties of the envelope materials. The experiments were conducted in different thermal environment to investigate the influence of the solar radiation, the environment temperature and the wind velocity, etc.

The remainder of this paper is organized as follows. Firstly, the experimental facility was introduced in detail, which includes the dimension and the material properties of the balloons, and the devices that used to measure the thermal performance of the balloons and the thermal conditions of the environment. Secondly, the procedure of the thermal experimental for sphere balloons under various conditions were outlined, with the experimental data analysed. Thirdly, the experimental data were used to validate a simulation model that was proposed by the authors of this paper. Finally, a conclusion was drawn from the results.

The experimental results suggest that the higher temperature Helium was gathered in the central and upper part inside the airship. The highest temperature area located in responded with the main heat resources, in the day time, it was on the upper part of the balloon and changes with the solar position, in the night time, it was on the bottom of the balloon. And the thermal radiative properties of the balloon envelope and the wind velocity may exert great influence on the thermal performance of the balloon.

The results of this paper could provide quantity data support for the balloon design, manufacture, mission planning and operation.

[A-004]

ANALYSIS OF TRANSIENT SURFACE TEMPERATURE AND AERODYNAMIC HEATING FOR SPACE EXPLORATION BALLOON

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The present paper reports on efforts to modelling and simulating the transient surface temperature and aerodynamic heating for space exploration balloon.

The space exploration balloon could be used in the in-situ detection of the plasma, electric and magnetic properties of ionosphere in the near space, or carry out space physics experiment in the upper atmosphere. It has superiority over the conventional space exploration system in respects of light weight, high load, low launch cost and high reliability.

The space exploration balloon was carried into the near space or upper atmosphere by a sounding rocket. During the ascending process, the balloon was folded and confined in the narrow chamber of the rocket. When the rocket reached its designed altitude, the balloon was released and instantaneously filled Helium. After the injection of the Helium, the balloon quickly reached its fully deployed status with the expansion of the Helium. Then, the exploration missions would be conducted throughout the balloon flight process.

The balloon was endowed with high initial ascending velocity while release from the sounding rocket. After the departure from the rocket, the balloon will confront complicated thermal environment with complex heat fluxes and affected by the resulting heat loads. The thermal environment of the balloon mainly comprises the radiation heat from the sun, the earth and the space, the convective heat transfer between the balloon and the atmosphere and Helium, and the aerodynamic heating due to the high initial ascending velocity.

A comprehensive understanding of the transient surface temperature and the effect of aerodynamic heating for the balloon is of vital importance in the balloon designing and mission planning, such as the enhancement of the reliability of the balloon and the determination of the release altitude.

To solve this problem, a thermal analysis model for the balloon was proposed, with the solar radiation, the long-wave radiation of the surrounding environment and convective heat transfer with the environment considered, and the heat transfer mechanism between the balloon and its environment was described in detail. The finite element method was employed to analysis the temperature distribution of the balloon surface, with the complementation of the user’s defined functions.

The effects of the aerodynamic heating due to the high initial velocity were inspected with the classic Ray-Riddell formulation, the aerodynamic heat flux on the windward and the stagnation temperature of the balloon was simulated numerically.

The results suggest that the release altitude and the initial ascending velocity may exert great influence on the surface temperature and aerodynamic heating of the balloon, and could provide quantity data support for the space exploration balloon design and mission planning.

Space-related Education 1

Thursday 15 June, Morning session – part 1

Chair: K.Dannenberg

Plenary Invited Lecture

[A-031]

10 YEARS OF THE GERMAN-SWEDISH REXUS/BEXUS STUDENT PROGRAMME

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Ten years ago on the 4th of June 2007 at ESA's 17th PAC symposium, held at Visby, the new REXUS/BEXUS programme was signed into life through a cooperation agreement between the German Aerospace Agency (DLR) and the Swedish National Space Board (SNSB). The Swedish share of the payload was to be made available to a wider European audience through a collaboration with the European Space Agency's (ESA's) Education office. This realisation of the REXUS/BEXUS programme fulfilled a joint ambition of DLR's Mobile Rocket Base (MORABA) and SSC's Esrange, jointly known as EuroLaunch, to invite students to regularly fly their experiments on sounding rockets and balloons.

On the 16th of November 2007 the first call for proposals was opened and in January 2008 five ambitious REXUS and seven BEXUS experiments were selected. The inaugural cycle of the REXUS/BEXUS programme cumulated with the launches of BEXUS 6 & 7 on the 8th of October 2008, and REXUS 5 & 6 on the 13th and 12th of March 2009 respectively.

Almost exactly 10 years after the DLR/SNSB agreement was signed, the REXUS/BEXUS programme has seen 20 launches and 129 experiments with participation of over 1000 students. Experiments have performed investigations in a diverse range of topics from atmospheric physics to biology and tested technologies in a range of areas, some of which have been developed to fly on other platforms such as Nano-satellites. Participants' work on REXUS/BEXUS experiments has formed the basis for hundreds of bachelor, master and PhD theses, as well as appearing in numerous peer-reviewed journals.

As the experiments have become more ambitious and challenging the programme has developed to meet the educational demands of the teams, become more complete, including additional reviews, schedule changes and new integration events for REXUS. In particular the intensity and technical support was reorganised and optimised. Looking to two feedback surveys, as well as registered participant information, it's possible to see a growing reach within European universities, an increasing satisfaction with programme participation as well as increased interest in, and realised, employment in the space industry.

[A-030]

THE STERN PROJECT – HANDS ON ROCKETS SCIENCE FOR UNIVERSITY STUDENT

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In April 2012, the German Aerospace Center DLR initiated a sponsorship program for university students to develop, build and launch their own rockets over a period of three years. The program designation STERN was abbreviated from the German "STudentische Experimental-RaketeN", which translates to Student-Experimental-Rockets.

The primary goal of the STERN program is to inspire students in the subject of space transportation through hands-on activities within a project structure, to motivate universities to supervise and support the student projects with the help of financial support and to increase the lecture activities in the field of launcher and propulsion systems. The STERN program incorporates a near space mission project life cycle, including preliminary, critical, integration and acceptance reviews, a thorough integration and testing campaign, launch and follow up activities.

The program is funded by the German Federal Ministry of Economics and Technology (BMWi) and managed through the DLR Space Administration.

The first STERN cycle is now almost finished. During the first cycle more than 460 students (status: 16.02.2016) have been involved in the program. Furthermore eight rockets during three campaigns have been launched. The paper presents an overview of its hands-on activities, highlights technical results and the operational improvements over the years.

[A-173]

PERSEUS

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Launched at the 2005 Paris Air Show, Perseus was conceived by the French Space Agency (CNES). PERSEUS is a french acronyme for "Projet Etudiant de Recherche Spatiale Européen Universitaire et Scientifique". The guide lines of PERSEUS are that the motivated students are invited to work on parts or global space launcher vehicles at a subscale of a Nano Satellite Launcher which corresponds to the more or less powerful experimental rocket. They can work either during the classical pedagogic frame proposed by their university, either in a space association or as researchers in a laboratory. The CNES with the help of partners is coordinating all these activities in order to achieve a complete life cycle of prototypes: objectives, studies, development, realization, ground or flight tests and data analysis. The number of partners has increased with respect of the progress performed by students. With CNES, there are 12 partners: AJSEP, Bertin Technologies, GAREF Aérospatial, ASL, IPSA, ISAE, MI-GSO, ONERA, Planète Sciences, Roxel France and the UEVE (University of Evry).

In the last ten years, the Perseus universities network has attracted more than 250 students per year, working on 60 projects, and some studies have extended beyond France, for several years, reaching students, researchers and space industries from different places in Europe. A step-by-step approach is the best way to guarantee a real progress in the demonstrators, while respecting a kind of management and procedures widely used in the aerospace industry.

A first overview of the project is necessary to integrate the different studies ending with ground demonstrations: avionics and electrical technologies applications (range of On-Board Computers and Inertial Measurement Unit), advanced propulsion technologies (bi-liquid propulsion), materials technologies (composite, combustion chamber, nozzle,...).

In order to qualify these concepts and technologies, different flight demonstrators are developed within the framework of PERSEUS.

- The successful flights of SERA-1 and 2, supersonic rockets launched from Kiruna, Sweden. It gave the opportunity to confirm the maturity of the electrical heart and to test innovative sandwich composite tubes and additive fab nose. The SERA-3 rocket should be launched in April 2017.
- The works on bi-liquid propulsion (MINERVA) has led to an engine (Lox/Ethanol). Several ignition tests (~4s) were successfully performed. The full combustion time of the tests are underway.
- A flying test bench was developed in order to test various separation systems of a rocket from the carrier. The airborne carrier, EOLE, has been developed and the flying campaigns have been performed successfully at Saint Yan Airport. New test campaigns are planned.
- More recently Vertical Take off and Vertical Landing demonstrators are under analysis by students

The manufacturing of the demonstrators is realized with machine tools available within universities or they can be developed in small enterprises.

PERSEUS is a project which is able to cut across the barriers between education, training and research.

[A-100]

FLY A ROCKET! A NORWEGIAN-ESA EDUCATIONAL PROGRAMME – PILOT CYCLE REPORT AND CONCLUSIONS

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The Fly a Rocket! programme pilot cycle was realised in late 2016 and early 2017. The programme is a collaboration between the European Space Agency's (ESA's) Education Office, the Norwegian Centre for Space related Education (NAROM) and the Norwegian Space Centre. Funding was provided by ESA, NAROM and the Norwegian Space Centre. Additionally ESA was responsible for participant selection and NAROM for the online course and campaign realisation.

Fly a Rocket!'s primary purpose is to promote and educate a select group of students from across Europe in the possibilities relating to careers and research in space through both an online course and hands-on experience of a sounding rocket campaign at the Andøya Space Centre. The target audience for the Fly a Rocket! pilot cycle was first and second year undergraduate students studying, but not limited to, engineering, physics, mathematics and other technical subjects. The target audience and training was intended to complement the current suite of hands-on projects offered by the Education Office.

The pilot cycle was initiated with a call for applications by the Education Office on the 3rd of October 2016, which proved extremely popular. Following a challenging selection process, 20 (and three reserve) students were selected to participate in the programme, each representing a different ESA member or cooperating state. From January to March the participants completed a technical online course and were encouraged to virtually meet one another and discuss their assignments and campaign preparations on a dedicated social media page.

The campaign took place in late March. Participants were divided into groups such as 'Telemetry', 'Rocket Physics' and 'Science', and completed a condensed sounding rocket campaign in just five days, including analysis, assembly, functional testing, launch and post-flight analysis of a campaign based on a NAROM-developed educational payload flown on a Mongoose 98. Throughout the launch procedure students were present in all 'stations', performing key mission tasks, such as 'Operations', 'Launch officer', 'Telemetry'. In addition students attended several training sessions and had a chance to visit the Alomar observatory.

The organising institutions are now assessing their lessons learned and the results of the pilot cycle with a view to creating an annual programme, with a the possibility of a new call for applications in Q3 2017.

[A-109]

DEVELOPING STUDENT LEADERSHIP IN SPACE SYSTEMS ENGINEERING VIA THE G-CHASER STUDENT ROCKET

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The G-Chaser Student Rocket Program represents an exciting opportunity for engineering and science students to participate in an international research campaign to study the cusp of the earth's magnetic field. The larger campaign, called "Grand Challenge", consists of seven scientific payloads from Norway, USA, and Japan (see www.grandchallenge.no) to be launched in December 2018 and January 2019 from Andøya, Norway. Penn State's participation in G-Chaser provides its students and faculty with an excellent opportunity to work with renowned atmospheric scientists from around the world and to develop continuing research collaborations with the science teams on the other Grand Challenge rockets.

The G-Chaser Student Rocket payload will be comprised of five to seven instruments built by students in Norway and USA, with further contributions from students in Canada and Austria. In the U.S., participants will be selected from proposals to be submitted in 2017 from universities with sounding rocket experience through the RocketSat X program administered by the Colorado Space Grant Consortium. Penn State has been selected to participate and play a critical role because of our experience with international student rocket programs. The *Esprit* rocket program was of a similar scale as the G-Chaser rocket, also encompassed a collaboration with three Norwegian universities, and flew successfully from Andøya in July, 2006. Over a dozen papers at conferences were published, most with students as lead authors. It was the success of the *Esprit* program that inspired the Norwegian Andøya Space Center to propose a student rocket be included in the Grand Challenge campaign.

Student-built rocket payloads are extraordinarily effective pedagogical tools and represent an extremely engaging, innovative educational tool, as there is significant real-world application, problem-based learning, and hands-on nature to them. Additionally, students are exposed to a complete life-cycle—conceive, design, build, fly, analyze, report—and must employ systems engineering processes to ensure success. Based on our experience with *Esprit*, we can attest that an international student rocket program is also well-suited to participatory cultural experiences and education for the formation of compitent engineers who are globally engaged. Even basic engineering training provides a confidence and an enthusiasm for this research that is seen to span national boundaries. G-Chaser is well-positioned to take full advantage of this enthusiasm and to encourage long-term friendship and collaboration among the students and faculty participants. This paper reports on some of the intial, formative activites of Penn State's contribution to G-Chaser.

[A-056]

STARBURST - A NEW, UNIQUE STUDENT PROJECT IN MARITIME SURVEILLANCE FROM SPACE

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The STARBURST project is a new, unique national Norwegian project in maritime surveillance from space where 15 selected, motivated students, primarily within the disciplines of engineering, physics, mathematics or other technical subjects, get the possibility to work with new space technology in Norwegian space companies.

The STARBURST project will introduce the students to a real industrial context, involving project management, design, development, integration, launch and release operations followed by results analysis, albeit in a very condensed timescale. The programme will provide practical project experience in direct interaction with professionals at KONGSBERG, NAROM and Andøya Space Centre and other Norwegian space companies.

This project includes hands-on activity for college and university students, and aims to take students through a complex system integration project, which concludes with the release of a stratospheric balloon carrying the student payloads. In addition, a full sounding rocket campaign will be performed at Andøya Space Center.

The project is organised by KONGSBERG and is a collaboration between KONGSBERG, NAROM, Andøya Space Center and other Norwegian space companies which all are members of NIFRO (Norwegian Industrial Forum for Space Activities). There are six KONGSBERG-companies participating in the project representing capacities from all sectors within the Space & Surveillance domain; from launcher equipment to downstream services. The other participating NIFRO companies are complementary in technology and product niches, and are selected in order to provide the STARBURST project with a complete set of resources necessary to obtain the project’s objectives.

The students will during the spring 2017 go through a net based introductory and training pre-course covering subjects related to space technology and maritime surveillance. During the whole project period (January - August 2017) the students will be part of a social media based discussion group with the other participating students. During an 8 weeks’ summer work period at a Norwegian Space Company the students will develop contributions to a STARBURST Stratosphere balloon payload. The final test, integration and launch of the student payload will take place at Andøya Space Center in the end of July 2017.

UTILISATION OF ROCKETS FOR RESEARCH APPLICATIONS 1

THURSDAY 15 JUNE, MORNING SESSION – PART 1

CHAIR: R.KIRCHHARTZ

[A-041]

THE RECENT DEVELOPMENT OF CHINA SOUNDING ROCKET SPACE EXPLORATION ACTIVITIES AND THE INTERNATIONAL COOPERATION

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Sounding rockets played an important role in the early stage of China's space development, and laid a solid foundation for today's Chinese Long March family launch vehicles. By the end of last century, China has developed 18 types of sounding rockets, and has completed various sounding rocket space exploration activities. Entering 21st century, China has developed the fourth generation of TK series sounding rockets, and its performance reaches the international level. As of today, China's TK series sounding rockets include TK-20, TK-30, TK-40 and TK-50 etc.

China actively explores international cooperation in sounding rocket space exploration activities, promoting the peaceful use of space and sharing the achievements of the space development. Based on the development of China's space technology, it explores the different international cooperation models in the sounding rocket space exploration domain with the global partners. Regarding the characteristics of different latitudes of the current China's launch sites, both sides can collaborate in the manner of exchanging experiment payloads with other international sounding rocket launch services providers. Meanwhile, China can carry out space exploration missions with joint investment and development, or providing the sounding rockets and related testing equipments/experiment payloads to the relevant industry globally. In addition, with the numerous launch missions planned in the next years, China can provide the piggyback opportunities to the potential international partners aboard its TK series sounding rockets starting from year 2018.

[A-045]

O-STATES & SPIDER/LEEWAVES, A NEW ERA OF NATIONAL SOUNDING ROCKETS FROM ESRANGE BEGINS

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In the autumn of 2015 and beginning of 2016 the three first rockets within the Swedish national balloon and rocket programme, initiated by the Swedish National Space Board (SNSB) in 2012, were successfully launched from Esrange. From the 1960's to the end of the last millennium one or two Swedish national sounding rockets were launched each year, not accounting for any of the many metrology rockets. These latest three rockets launched over the past two years mark the beginning of a new era for advanced research by rockets from Esrange, available for Swedish scientists.

O-STATES 1 & 2 (Oxygen Species and Thermospheric Airglow in The Earth's Sky) from the Metrological Institute at Stockholm University (MISU) were launched in October 2015. The one payload was launched twice in a single campaign with an abbreviated on-site refurbishment between flights, for time and fund efficiency.

SPIDER/LEEWAVES (Small Payloads for Investigation of Disturbances in Electrojet by Rockets / Local Excitation and Effects of Waves on Atmospheric VErtical Structure) was a collaboration project between KTH, Royal Institute of Technology and Stockholm University. SPIDER from the Space and Plasma physics department of KTH and LEEWAVES from the Metrological Institute at Stockholm University (MISU). These two missions were launched as a combined payload in February 2016. Both missions used free-flying instrumentation ejected from the main payload.

This paper reports on the O-STATES 1 & 2 and SPIDER/LEEWAVES missions and flights, focusing on the related technical solutions and results.

[A-046]

DEVELOPMENT OF NEW PAYLOAD MODULE FOR 4D MEASUREMENTS

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Traditionally the sounding rocket carries a payload in which all instruments are mounted in a payload section on the main rocket body. A nosecone and/or doors protects the payloads' instruments during the rockets' ascent until the area of interest has been reached and nosecone and doors are ejected to expose the instruments.

Although the sounding rocket can reach areas of the atmosphere to perform in-situ measurements that balloons and satellites cannot, it only performs such measurements during a very brief moment in time and at particular place governed by the ballistic trajectory of the rocket.

To be able to determine the dynamic properties of a particular phenomenon or the scale of such phenomena, it must be possible to perform measurements covering a larger area as well as over an extended time interval than what is possible with a single sounding rocket payload.

In order to allow researchers to see a bigger picture of the phenomenon that is being investigated, Andøya Space Center (ASC) has initiated a development of a new payload module for sounding rockets that will allow for 4 dimensional (4D) measurements (3D space and time). The purpose of the new development is to be able to eject a large number of miniaturized payloads in different directions at predefined times during the ascent of the rocket. The miniature payloads carries the identical instruments and sensors, which then allows for measurements to cover a much larger area and thus form a 3D mapping. Depending on the direction the miniaturized payload is ejected, a measurement of the same position at different times during the flight of the rocket is possible. As such, the free flying miniature payloads can be seen as forming a cloud. While they propagate along the ballistic path of the sounding rocket the fourth dimension, time, is realized.

The first phase of the project is to flight qualify a module that fits on a 14inch payload. The module will release several daughter payloads into one plane, making 3D measurements (2D space through time). The system is easily scalable to fit larger payloads and to add more daughter payloads as necessary.

The development of the new payload module is done in close collaboration with the University of Oslo and their 4DSpace initiative.

[A-131]

MIRKA2-RX – AN EDUCATIONAL PRECURCOR MISSION FOR A RE-ENTRY BASED CUBESAT MISSION

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Scope

The MIRKA2-RX mission was part of the REXUS/BEXUS program by DLR/SNSB and performed an in-flight validation of a mock-up version of the MIRKA2 micro-return capsule[1] as a free-falling unit that was ejected from the REXUS19 rocket on the 18th of March 2016. The experiment was built by students from the University of Stuttgart, which are members of KSat[2]. They worked in collaboration with the Institute of Space Systems (IRS). It serves as a demonstrator for a potential flight on the CubeSat CAPE[3] (CubeSat Atmospheric Probe for Education).

Experiment Setup

The setup of MIRKA2-RX experiment is divided in two distinct autonomous systems, the capsule and the experiment module. The capsule is the smallest re-entry capsule to date[1]. It contains several sensors and an Iridium transceiver is used to transmit data to a ground station. The experiment module houses the separation mechanism containing the capsule as well as an electronic compartment. The custom-made separation mechanism fits within one CubeSat Unit (10x10x10 cm^3) to be compliant for CubeSat applications[4]. The capsule is secured to a carriage, which is locked in position by using a wire. When the separation is triggered the wire is cut. The electronic compartment inhabits an on-board computer (OBC), a pyrocutter control-board and a mirrored system of the capsule electronics. Furthermore, two cameras are in the experiment module to observe the ejection.

Results

The ejection of the capsule close to the apogee worked nominally, namely hatch and capsule ejection were successful. Both cameras recorded the ejection procedure. The video material allowed to calculate the separation velocity to approximately 0.775 m/s without any significant tumbling movement. The OBC worked nominally at all stages of the flight and besides the separation successfully triggered the mirror system and received the measured data.

Unfortunately, the capsule did not activate during flight, as planned. This was a result of the jammed activation mechanism inside the capsule. The jammed pin was released upon impact. This activated the capsule's electronic system which sampled sensor data. The capsule sent 64 messages in 29.7 minutes before the battery capacity expired. The transmitted GPS data made a recovery of the capsule buried under approximately 40 cm of snow possible. The post-flight analysis showed no significant damage to the capsule and linked the activation issue to the jammed activation pin. The analysis of the capsule's as well as the mirror system's measurement data showed a convincing performance.

Impact on future missions

The MIRKA2-RX mission showed that building a capsule which contains relevant sensing, processing and communication capacities is feasible. Several design improvements could be derived which were addressed in the next versions. A slightly improved electronic system flew on the 8th November 2016 on board the HEROS III hybrid rocket built by the HyEnD student team from the University of Stuttgart. To address the activation difficulties, another fully integrated capsule mock-up will be flown in spring 2017 in South Africa. The potential flight on the CubeSat CAPE is the goal in the development of a functional re-entry capsule.

[A-049]

EXPERIMENTAL RESULTS FROM THE TESTING OF THE PROTOTYPE INFLATABLE CONICAL ANTENNA – REXUS DEPLOYMENT ON REXUS FLIGHT RX19

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Inflatable structures provide a solution to several of the issues faced in the development of CubeSats; for example they allow for the deployment of larger structural elements necessary for long-range radio applications. Inflatable structures in space have several issues, such as their inherent lack of structural strength (particularly after loss of pressure due to leaking over time or punctures caused by micrometeorite impact). Metal-polymer strain rigidisation is one technique which can be used to add strength and improve long-term usability of such structures.

The Prototype Inflatable Conical Antenna REXUS Deployment (PICARD) experiment was developed as a technology demonstrator for a Wideband Radar antenna to be deployed from a CubeSat via inflation. The antenna design is one of the candidates for the Wideband Ionospheric Sounder Cubesat ExpeRiment (WISCER), a previously proposed mission to measure the impact of ionospheric interference on UHF radar images of the earth taken from orbit. A novel partial surface metal-polymer strain rigidisation technique was used to ensure the structural integrity was maintained even with loss of pressure. The experiment was flown on March 18th 2016 on board the RX19 sounding rocket as part of the SNSB/DLR REXUS/BEXUS programme.

We present the results gathered from the flight in addition to an analysis of the performance of the various experiment subsystems. Our recovered data indicates that the inflation and rigidisation was successful and the antenna's RF performance was not decreased by the deployment.

Utilisation of Balloons for Research Applications 2

Thursday 15 June, Morning session – part 2

Chair: V.Dubourg

[A-005]

HIGH ALTITUDE BALLOON LAUNCHED MICRO GLIDER: DESIGN, MANUFACTURING AND FLIGHT TEST

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Autonomous, swarming micro air vehicles gliding from stratosphere and precisely landing with the equipped sensors to a mission area shows a new concept for scientific use. As a pre-research, this paper presents an overall design and manufacturing of a high altitude balloon launched convert disposable micro glider.

The overall parameters analysis including maximum range, gliding velocity and gliding path is based on the simplified re-entry equation. For specific, the aerodynamic parameters in the re-entry equation are estimated from the wind tunnel tests of various planform flat-plate wings. Response surface method is adopted for the wing size optimization. According to the optimization results, the inverse Zimmerman planform with low aspect ratio 2 (span length 22 cm) is determined as the flat-plate wing configuration. Detailed aerodynamic design including flight trim and stability analysis is carried out with vortex lattice method. The trim results shows that the control surface of the flat-plate wing should have a 3 degree upward deflection for maintaining the stable flight.

For the manufacture of the aircraft, the printed circuit board is selected as the wing material and electronic components are directly integrated to the wing surface. Main equipments for autopilot include attitude sensor, GPS, gyroscope and servo motors. The position of the lightening holes is close to the trailing edge for adjusting the gravity center demand.

The first stage of the design and manufacturing of the micro glider have been completed and the flight test conducting by launching from a height of 50 meters shows a stable flight performance. In the next step, the balloon-carried launcher system and the flight control system will be developed and the real high altitude balloon launched experiment will be conducted in June, 2017.

[A-073]

DLR ELAHA – CURRENT DEVELOPMENT STATE OF AN UNCONVENTIONAL STRATOSPHERIC UAV

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The group *Flying Robots* at the *DLR Institute of Robotics and Mechatronics* in Oberpfaffenhofen conducts research on electric/solar powered high altitude aircrafts.

Following the feedback and interest regarding the presentation of HABLEG on ESA PAC 2015, work continued regarding the development of a tool to reach the stratosphere besides balloons and rockets.

While HABLEG was a glider, being carried to the stratosphere by balloon, the work concentrates now on means to reach the stratosphere under own power, thereby reducing greatly the dependency on suitable wind conditions and allowing for a fixed flight trajectory.

ELAHA, of which already a smaller engineering prototype exists and of which currently a 9m wingspan version is being built, uses an unconventional approach regarding aircraft design. If proven successful, it could pave the way for future larger versions.

The paper will give insight on the very latest development state of the system, while, as last time, the talk will be very media heavy.

Suggestions to possible collaborations, with the goal to carry scientific payloads during flight test campaigns, are explicitly welcome.

[A-078]

Results from the Inflatable, Textile and Rigidisable Antenna (INTEX) Experiment on the Bexus 21 Mission

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The InTex experiment developed and tested a novel approach for inflating antenna structures for space and terrestrial applications. Instead of using polymer based or metallic foils, a hybrid textile material was utilized. The Intex experiment introduced a cotton fabric, coated with a thin PVC layer to ensure air-tightness. Since leakage is a major risk for almost all inflatable structures a UV cured epoxy rigidisation was applied. The experiment was conducted on a stratospheric balloon flight within the the BEXUS 21 program. To prevent premature curing of the rigidization polymere the antenna was stowed in a heated, light-tight container. At the apogee of the balloon flight the container was opened and the inflation took place. The antenna became inflated and the epoxy cured due to UV irradiation by sunlight. Afterwards, a leakage was enforced to proof the success of the stabilization approach. The experiment has been monitored by two high resolution cameras and the electrical properties as well as important environmental factors such as pressure and temperature of the antenna where measured continuously.

The paper is divided into three sections. First, selection of the cotton based textile material, the sealing approach as well as the choice of rigidization polymere will be covered. This includes a short survey about materials that were used for other experiments as well as common rigidization technologies. Secondly, the electrical and mechanical design of the antenna and the supporting mechanical as well as of the electrical structure will be explained. This includes the potential but also the limitation of geometries produced by sewing, knitting and braiding and its impact on the antenna design.

Finally, the results of the experiment are presented and discussed. The experiment has been carried out successfully and performed as expected. However, we noticed serious outgasing of the epoxy in the stratospheric enviroment. On the subsequent Bexus 22 mission we were able to demonstrate a sealing approach to mitigate this adverse effect.

[A-101]

BEXUS 23 OSCAR: SOLAR CELL I-V MONITORING SYSTEM FOR SPACE ENVIRONMENTS

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The OSCAR ('Optical Sensors based on CARbon materials') project aims to explore the use of novel generation carbon based (i.e. polymer, small molecule, perovskite, flexible) solar cells for aerospace applications through in-situ testing during a stratospheric balloon flight. Complementary ex-situ testing before and after flight is performed to observe and understand the impact of the harsh environmental conditions. It is the mission of this project to get an indication of the degradation of the carbon based solar cells when exposed to space-like environments. This could possibly unveil their deployability in aerospace applications, for which these devices' very high power-to-mass ratio makes them excellent candidates.

To achieve this mission goal, a custom I-V (current-voltage) performance monitoring system for a population of 64 solar cells was implemented. The design period identified a set of strict requirements such as low mass, low power, adequate measuring speed, optimal resolution, measurement accuracy, error handling, stability, resistance to software resets, data communication, and data logging, which were successfully addressed in the final build. Furthermore, the cells were divided into 3 different categories based on their operational I-V ranges (BCF, DEdiode and IPV+STRETCH). Each of these had a characteristic applied voltage range, which were from 0 to 1V, 0 to 0.85V, and 0 to 7V, with corresponding current ranges of -6 to 14mA, -5 to 5mA, and -200 to 500mA, in the cited order. By using all 11 effectively available ADC bits within these ranges, measuring accuracies could get as low as 0.5mV and 10uA for BCF, 0.4mV and 5uA for DEdiode, and 3.5mV and 350uA for IPV+STRETCH. Timewise, there was the requirement of acquiring at least one I-V sweep per device every 5 minutes, in order to have enough data. Moreover, the time between measuring the first and last point within a single sweep was not to exceed 20s, to guarantee minimal changes in received sunlight within measurement curves. In this work, solutions to issues ranging from connector reliability to OPAMP ringing and RF interference, will be explained.

In the end, it will be shown that this measurement system has proven to function continuously for a period of 4h (until battery drainage) while being exposed to low temperatures down to -50°C, low pressures down to 6 mbar, and RF interference. All data show consistent I-V measurements, yielding a data set of 192000 IV characteristics acquired during flight, currently being analysed for further research and upcoming communications.

[A-147]

FINDINGS OF THE PREDATOR EXPERIMENT – BEXUS 23

Bc. Jan Lukačevič[1], Ing. Pavel Paces Ph.D.[2], Bc. Zuzana Tůmová[3] Michal Gabriel[4], Ondřej Trojan[5], Miloš Hampl[6]

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The aim of The PREDATOR Experiment is to verify a new pressure difference method of which implementation would lead to introduction of new, more precise measurement devices used in the aircraft navigation systems. PREDATOR (PREssure Difference dependency on Altitude verificaTOR) is a verification experiment that has been developed and conducted by a student team consisting of undergraduate and graduate students from the Czech Technical University in Prague within the REXUS/BEXUS programme and is fully supported by the European Space Agency. Objective of the experiment is to verify a new measurement method using a specific arrangement of the pressure sensors in a particular setting enabling to determine the limits and feasibility of a measurement method. If successfully implemented, such method has a wide range of use for further improvement of current AHRS (Altitude Heading Reference System) in aircraft and can improve future navigation systems. The experiment is based on a previous research at Czech Technical University and it has been tested in conditions of a scientific laboratory, in a natural environment using UAV and small commercial aircraft.

This article describes the final experiment execution and results of a flight that happened in September 2016 at Esrange Space Center near Kiruna. We present the data acquired during the flight and widely focus on findings and consequences. Currently gathered measurement data so far suggest the validity of the method and will be further examined in order to be presented in detail during 23rd ESA PAC Symposium.

[A-151]

BALLOONS AND SOUNDING ROCKETS – PLATFORMS FOR DROP TESTS

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Stratospheric balloons and sounding rockets can provide an ideal platform for performing re-entry and other high speed tests off different types of vehicles and techniques. It is also an ideal platform for testing different types of recovery systems such as airbrakes and parachutes. Stratospheric balloons has a capacity to lift a mass up to 3.5 tonnes and can reach 40 km altitude, equivalent to an atmospheric pressure of 3 mbar. The payload or test object (re-entry vehicle, parachute system, etc.) that shall be tested can be equipped with telemetry and tele-command system for real time monitoring and control during the complete flight and free fall. The test object is lifted up by the balloon to the required altitude and released by command from ground.

Swedish Space Corporation's (SSC) stratospheric balloon and sounding rocket launch facility Esrange Space Center in northern part of Sweden offers the ideal place including the large impact area of 5600 km^2 where the free falling test objects can be dropped safely.

Sounding rockets launched from Esrange can also be used in a similar way for higher altitude but with a lower mass test objects. Rockets with different capacities can be launched up to 700 km altitude and can carry a payload up to 600 kg. The test object is ejected from the rocket and performs free fall towards ground and impacts in the vast Esrange ground impact area, to be recovered afterwards.

This paper will provide an overview of drop tests performed – and to be performed – from Esrange, using balloons and sounding rockets as platforms.

[A-062]

BALLOON MICRO LIFEFORM-AND-METEORITE ASSEMBLER (BULMA) EXPERIMENT FOR BEXUS 22 LAUNCH CAMPAIGN

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The BuLMA (Balloon micro Lifeform-and-Meteorite Assembler) experiment is an advanced form of a particle-recuperating machine, belonging to Students' Space Association of Warsaw University of Technology PARTICULA balloon experimental programme. The first PARTICULA experiments were based mostly on stratospheric sails ('parachutes') of different sizes, which, equipped with magnetic elements, were flown in 2013 under latex balloons to 30 km of altitude to collect iron (chondritic) spherules and additional particles. An alternative to sail-magnetic experiments (due to their problematic use in flight), travelling in low velocities and having contact with a quite low total volume of air (resulting in lot total number of caught particles), is a stratospheric aerodynamic device based on multiple cyclone unit equipped with fans, able to collect not only micrometeorites and dust particles, but also so-called mesoxenes, or microorganisms that originated from the Earth but no longer resemble Earth-like lifeforms (all done using electric field, magnetic field and membrane filters). A mission duration of a few hours in the stratosphere (above 12 km of altitude) and much greater total volume of used air (air in contact with particle-collecting instruments) was expected to increase the number of caught particles. The planned collecting device was built for tests in 2014 (air ducts optimization, particle path tracing, friction reduction, sealing, integration); on 5th October 2016 the experiment was flown onboard the BEXUS 22 balloon mission from Esrange, Sweden. Furthermore, an adaptation of the experiment for the use onboard the Ares II Mars rover was made (TRUNCS, of Terrain-Roving Universal Nacelle for Collection of Samples – it performed an on-board in-field analysis of a 'Martian' dust portion, set similarly to the BuLMA planned analysis). The final analysis of the BuLMA experiment included microscopic research on caught particles (including coloration allowing the distinction of different particle types) and laboratory grooming (inoculation on different substrates) of caught microorganisms (for further investigation). For 2017 additional metagenomics analysis and r-RNA research are also planned.

SPACE-RELATED EDUCATION 2

THURSDAY 15 JUNE, MORNING SESSION – PART 2

CHAIR: M. BECKER

[A-064]

SALACIA – A STUDY OF MARTIAN BRINES WITH REXUS 21

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The search for water has been one of the main focuses within the space and planetary exploration community for a long time. Data taken by the Mars Science Laboratory (MSL) has recently indicated that there is in fact an active water cycle on Mars. This water cycle is thought to be driven by a process where chlorate and perchlorate salts commonly found on the Martian surface absorb atmospheric water and transition into a liquid state, a brine. Due to its importance for the future exploration of our red neighbour, the ExoMars 2020 mission will include an instrument, HABIT, to further investigate the water cycle.

Students at Luleå University of Technology have developed SALACIA, a REXUS/BEXUS sounding rocket experiment, with the aim of studying the properties of these Martian salts prior to the ExoMars 2020 launch. By flying a selection of the salts on a REXUS rocket, SALACIA will investigate their behaviour through different atmospheric layers, up to 90 km altitude. The primary objective of the investigation will be complemented by camera recording, providing visual indications of their behaviour.

Pressure, composition, humidity and temperature will change at different altitudes, with some of the altitudes representing Mars-like conditions in these aspects. The amount of absorbed water is observed by measuring the change in conductivity for the salts during the whole flight, while the atmospheric changes are either directly observed by SALACIA, or inferred from the state of the rocket.

Additionally, working as a pre-study for HABIT, SALACIA will help to identify and understand critical behaviours of the salts in preparation for ExoMars 2020. The SALACIA experiment is realized by a group of sixteen university students studying space science and engineering at Luleå University of Technology in northern Sweden, and will fly with REXUS 21 in March 2017.

[A-127]

FREON DECAY EXPERIMENT ON BOARD OF BEXUS-21 FLIGHT

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FREDE 2015 experiment aims at providing a better understanding of how chlorofluorocarbon compounds (CFCs' - a group of refrigerants commonly known as Freon's) disintegrate in contact with UV radiation present in Earth's atmosphere under high and low altitude conditions, especially with the test compound brought to altitudes that range up to 28 km above Polar Circle. Depletion of the Earth's ozone layer (O_3) and the increase in the greenhouse effect is well known fact related to CFCs' emissions.

In order to perform research of the CFC compounds' behavior in the Earth's atmosphere, project FREDE 2015 was designed to carry out two major experiments: one in a laboratory and the other using a stratospheric balloon.

A set of experiments conducted in a ground laboratory was essential to form a thesis which concerns actual decay time of the selected CFCs, kinetics and the products of their chemical reactions. These reactions are mainly influenced by cosmic radiation. All this information were crucial for the success of the experiment performed during balloon flight campaign.

Selected compound (CFC-12) mixed with inert gas was contained in a separate 4 airtight gas bag which served as a reservoir for the CFC samples exposed to atmospheric conditions. The experiment required for each bag to be connected with a measurement chamber through a dedicated pneumatic system. In the measurement chamber an array of sensors (Electron Capture Detector) monitored the CFC's concentration level as well as the temperature and the pressure for each test sample. The collected set of information was stored in the memory of the on-board computer while a backup copy was sent to the ground station. To prevent an undesired air contamination the test sample was cleaned in so called Zeolite Filter.

FREDE Experiment was sucesfully launched on board of BEXUS-21 mission from Esrange on 7th of October 2015. Obtained results confirmed that design apparatus performs well in startospher. However difficulty in simulation of flight conditions in ground laboratory prevents us from execution of proper comparative analysis.

Project FREDE 2015 is a result of an interdisciplinary collaboration between students from several major faculties at the Wroclaw University of Technology and one faculty at the University of Wroclaw. Goal of the project is to bring a fresh perspective in the area of ozone depletion process, climate change, as well as stratospheric in-situ measurements.

[A-093]

USING A HABDUINO FOR TELEMETRY IN ARCTIC ATMOSPHERES AS A HANDS-ON SPACE EDUCATION PROJECT FOR SECONDARY SCHOOL STUDENTS

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The HABduino project is an open source shield for the Arduino Uno. The main purpose of the HABduino is to send the position and altitude of a high-altitude balloon with radio telemetry.

A group of students from the secondary school Stedelijke Humaniora Dilsen used a high-altitude balloon with an Arduino and sensors to determine the altitude of the tropopause above the Norwegian archipelago Svalbard. As retrieving a balloon in the inaccessible environment of Svalbard is not to be expected, a HABduino shield was used to send the data gathered by the Arduino to a receiver. Although the HABduino was not developed to send custom data, the students managed to adjust the code so it could send their own data.

The main scientific purpose of the project was to determine the altitude of the tropopause in an arctic atmosphere. A temperature sensor and a humidity sensor were used to achieve this goal. The measurements were sent to the HABduino through serial communication before sending them to the receiver. Two balloons were used to reduce errors.

In order to minimize costs of an expedition to Svalbard, this project was executed in collaboration with two other secondary schools, i.e. Sint-Pieterscollege Jette in Belgium and St Paul's School from London. However, each school had its own scientific project.

[A-112]

WOLF REXUS EXPERIMENT

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WObbling controL system for Free falling unit (WOLF) project is closely related to an experiment called SPIDER (Small Payloads for Investigation of Disturbances in Electrojet by Rockets, presented in other contributions to this meeting), which was developed under the Swedish National Balloon and Rocket Programme. SPIDER carried a payload of ten Free Flying Units (FFU) which were ejected from the main rocket at about 65 km. The FFUs deployed spherical probes on wire booms to measure electrostatic turbulence in the auroral electrojet between 95 km and 115 km.

Those FFUs experienced a wobble motion, likely induced during the FFU ejection from the rocket. The wobbling motion of the probes may compromise measurements on the spinning payloads with flexible booms, as the position of the probes cannot be assumed radial. In the worst cases, wobbling can affect the dynamics of the free flyers to the extents affecting the mission.

The WOLF REXUS experiment sets out to address this issue, aiming to demonstrate a dynamical system for suppressing the wobbling, and ensuring flat spin motion on disc-shaped FFUs. The experiment also addresses the effect of the FFU ejection on the main rocket attitude dynamics, and develops a more robust recovery and localization system to be used in future FFUs of this class. The WOLF experiment was selected for flight onboard RX24 sounding rocket, realized in the framework of the REXUS/BEXUS programme.

This contribution describes the setup of the WOLF experiment, and presents the progress up to the Critical Design Review level.

[A-067]

BIFROST PARABOLIC FLIGHT: A NEW RECURRENT HANDS-ON SPACE EDUCATION PROGRAMME FOR SECONDARY SCHOOL STUDENTS

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Hands-on space education projects for high school students have been organised by various institutions and individuals with broadening scope for over ten years. The rationales underlying the logistics of these projects are diverse though, and have evolved considerably in that period. While sparse and single-shot in the beginning, project recurrency has been recognised as a key enabling feature by most organisers. In other respects though, formats are still considerably different from each other, reflecting fundamental choices.

In Belgium a recurrent hands-on High Altitude Balloon programme called Asgard has been running succesfully since its inception in 2011. The Asgard format is copied to a large extend on the way space agencies model their deep-space science missions: a flight is planned (here, a latex balloon flight to approximately 30km) and a call for proposals launched, in this case to secondary schools. Interested teams can submit a proposal for a scientific (or technical) experiment, and a jury selects those projects deemed most worthwhile, within the payload mass (and other) constraints of the mission. Once the teams selected, there is no competition anymore, no medals to be won or jury to be convinced. What remains are teams of youngsters eager to make their mission as good as it can be, to help each other as well as they can, and to learn as much as possible.

Now a new hands-on space education programme, involving parabolic flight, was initiated (after a precursor edition in 2014) along lines comparable to - though somewhat different from - those of a Cansat competition. Called Bifrost ('Brussels Initiative to provide Flight Research Opportunities to STudents'), this programme aims to motivate upper high school students for STEM studies (Science-Technology-Engineering-Mathematics) by offering the opportunity to fly an experiment (and possibly a team of 5 students plus a teacher!) on a parabolic flight, flown with Delft University of Technology's Cessna Citation II flying laboratory. Where Asgard offers access to the near-space environment, Bifrost offers bigger payload capabilities, a microgravity environment (a dozen 15s parabolas) and possible in-flight human intervention.

In this paper we will report on the logistics of this year's so called 'Bifrost One' edition, and highlight both similarities and differences when comparing Bifrost parabolic flight to Asgard high altitude balloon missions. Furthermore, the technicalities of parabolic flight with TU Delft's Cessna Citation II will be discussed, and some of the experiments flown by the different teams presented as examples.

[A-052]

ASSESSMENT OF THE VHF OMNIDIRECTIONAL RANGE (VOR) PERFORMANCE IN THE STRATOSPHERE: STRATONAV ON BEXUS 22

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The VOR (VHF Omnidirectional Ranging) is an aircraft navigation system designed in the 1940s to safely navigate on pre-determined routes by giving an indication on the aircraft relative position to the destination airport. The system architecture is based on ground stations, that transmit a specific signal, and on airborne receivers able to decode it and to extract the "radial information", equal to the aircraft bearing with respect to the ground station magnetic North. Although newer positioning systems have been developed, the VOR is still used as a backup navigation system. Even though the VOR service volume usually extends to 185 km in range and 18 km in altitude, link budget estimates indicate that the system could correctly operate beyond these operational boundaries. There is no information available on the VOR performances above the service volume limit, due to the absence of civil aviation vehicles able to fly at those altitudes. However, the VOR could enhance the reliability of future stratospheric aircraft navigation systems, if used alongside other radio and inertial navigation systems. Moreover, the high altitude extended field of view could offer a larger number of ground stations in line of sight, allowing to perform a VOR-stand-alone position determination.

The purpose of STRATONAV (STRATOspheric NAVigation) Experiment was to evaluate both the reliability and functionality of the VOR in the stratosphere. The experiment was selected for the REXUS/BEXUS Programme Cycle 9 (Rocket/Balloon-borne EXperiments for University Students) and it was launched on a stratospheric balloon from the Esrange Space Center in Kiruna, Sweden, on October 5th 2016. The experiment was developed by a joint students team from Sapienza - University of Rome and Alma Mater Studiorum - University of Bologna. The scientific project included the experiment concept, design, test, launch and post-flight data analysis. The aim was to receive the signal from the several VOR stations in the scandinavian area.

The acquired data proved that the VOR maintains an adequate reliability at high altitude with the current ground stations architecture, without the need to upgrade existing systems. This establishes that the VOR can be used in the stratosphere as a low-cost standalone positioning system or as a back-up system.

This paper provides a detailed description of the STRATONAV Experiment concept, design and development. Moreover, an accurate flight report and a results overview will be presented.

[A-094]

TRAJECTORY ANALYSIS OF THE HYBRID SOUNDING ROCKET HEROS

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HEROS (Hybrid Experimental Rocket Stuttgart) is a hybrid sounding rocket designed and built by the student group HyEnD of the University of Stuttgart. It was developed for the STERN (student's experimental rockets) project funded by the German Federal Ministry for Economic Affairs and Energy. The STERN project was coordinated by the German Aerospace Center Space Administration. HEROS was successfully launched from ESRANGE, Kiruna in November 2016. With its apogee altitude at 32.3 km, it set a European altitude record of student rockets. This paper discusses the trajectory analysis for the HEROS campaign.

Pre-flight analysis was conducted to predict the impact of different engine configurations on the rocket's trajectory. The engine model was created with EcosimPro/ESPSS (European Space Propulsion System Simulation), which has been developed on behalf of ESA. The resulting thrust curves were validated in ground testing. ASTOS was used for the trajectory analysis. The simulation data was also used to analyze the flight environment, so that the aerodynamic and thermodynamic loads on the vehicle could be taken into consideration. Early estimates of the impact/landing area were required for flight safety evaluation. Wind Weighting Curves were calculated which give a reference for the behaviour of the rocket with different winds.

During the launch campaign, wind conditions were further taken into consideration. Winds are capable of changing the trajectory in a way, that recovery system or flight safety requirements are not met. Additionally, a more precise prediction of the impact point was calculated based on the latest weather forecast. Post-flight, the data recorded on the rocket during flight was used to refine the simulated trajectory so that the flight could be represented more accurately. This way, a better understanding of the characteristics of HEROS in flight could be reached.

UTILISATION OF ROCKETS FOR RESEARCH APPLICATIONS 2

THURSDAY 15 JUNE, MORNING SESSION – PART 2

CHAIR: W. JUNG

[A-136]

TEXUS - LATEST DEVELOPMENTS AND NEW PERSPECTIVES

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In December 1977 the first TEXUS launch was successfully performed from the Esrange Space Center in Sweden with the German Space Agency DLR as customer. It marked the beginning of the successful Sounding Rocket Program for research under microgravity conditions at Airbus. Until end of 2016 a total of 6 MiniTEXUS, 53 TEXUS and 9 MAXUS missions were flown for DLR and the European Space Agency ESA under Airbus responsibility.

In 2017 three more launches are scheduled: MAXUS 9 for ESA and TEXUS 54 & 55 for DLR. Onboard these rocket flights are several newly developed experiments which will be presented.

Recently several sounding rocket experiment modules have been adapted to other platforms - such as the ZARM drop tower, Novespace parabolic flights or the ESTEC large diameter centrifuge - some for validation purposes others to complement the TEXUS or MAXUS flight experiments. This flexibility leads to improved concepts for the operation of the core experiment unit via a harmonized and standardized interface, in the future potentially to be implemented on free-flying capsules and the International Space Station. Simplified portability has two significant advantages: it is very cost efficient and it improves the scientific evaluation and comparison of experiment results since the same hardware can be used on different microgravity platforms.

[A-033]

MINI-IRENE: THE FIRST EUROPEAN FLIGHT EXPERIMENT OF A DEPLOYABLE HEAT SHIELD

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MINI-IRENE is the the Flight Demonstrator of IRENE, a new-concept capsule with a variable geometry, originally conceived by ASI to widen the range of available platforms to retrieve payloads and/or data from low Earth orbit.

The main characteristics of IRENE is the "umbrella-like" deployable front structure that reduces the capsule ballistic coefficient, leading to acceptable heat fluxes, mechanical loads, stability and final descent velocity.

The feasibility study of the IRENE deployable re-entry system has been carried out in 2011. The TPS materials, selected for the nose cone and for the flexible umbrella shield, have preliminarily been tested in the SPES hypersonic wind tunnel at the University of Naples, and in the SCIROCCO Plasma Wind Tunnel at CIRA. Such successful tests and the preliminary experimental results proved the concept feasibility and the viability of commercial materials for low-cost re-entry nacelles.

Based on the initial results, the European Space Agency supported a study to preliminarily address the main issues of a reduced-scale IRENE demonstrator, called MINI-IRENE, to be embarked as a piggy-back payload in a future mission of a sub-orbital Maxus sounding rocket.

After the preparation phases A and B were successfully completed, the European Space Agency funded the current phase of the program. The object is to design and built a Flight Demonstrator and a Ground Demonstrator to prove, with a suborbital flight and with a Plasma Wind Tunnel (PWT) test campaign, the functionality of the deployable heat shield.

The Flight Demonstrator shall be included as a secondary payload in the interstage adapter of a Mapheus launcher from ESRANGE. It shall then be ejected during the ascent phase of the payload section, after its separation from the booster at an altitude of about 150 km, perform a 15 minutes ballistic flight, re-enter the atmosphere and hit the ground. The Ground Demonstrator, representative of the Thermal Protection System of the Flight Demonstrator, shall be instead exposed to a heat flux similar to that expected for an atmospheric re-entry from low Earth orbit inside the SCIROCCO Plasma Wind Tunnel at CIRA.

This paper describes the roadmap of the IRENE concept, providing details concerning the heritage and past activites, together with the next qualifications tasks that will be performed in order to converge to the development of the space system IRENE.

[A-135]

MINIATURIZED SUB-PAYLOAD FOR MULTI-POINT IN-SITU MEASUREMENTS ON THE G-CHASER STUDENT ROCKET

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We will present a miniaturized sub-payload to investigate time and spatial variations in plasma irregularity regions by multi-point in-situ measurements.

With 1D sampling by rockets it is not possible to un-ambiguously discriminate between quasi-stationary wave and turbulent irregularity structures. Indeed, each measurement is made at a precise location in time and space, but due to the relative motion between the rocket and the plasma, a limited picture of the spatial-temporal evolution of the plasma structures is obtained. There is a need to develop 4D Space measurement techniques (3D in space + Time). As part of the Grand Challenge Initiative (GCI) we will instrument the G-Chaser student rocket with the 4DSpace module invented by Andøya Space Center. This module hosts 6 sub-payloads which will be ejected from the rocket in flight. Each sub-payload will be equipped with the miniaturized multi-needle Langmuir Probe instrument (m-NLP) in addtion to an electron emitter to control the platform potential.

The G-GHASER apogee will be 190 km, and we will cover the ionosphere E-region and the lower F-region. It will be a technical flight and the aim for this experiment is to test the technology and to obtain the first 3D measurements of small scale plasma structures.

[A-083]

DETAILED PHOTOCURRENT CHARACTERIZATION FOR METEOR SMOKE PARTICLE DETECTORS ONBOARD THE PMWE SOUNDING ROCKET

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Polar mesospheric winter echoes (PMWE) are enhanced radar returns from altitudes of 55 to 85 km and their formation mechanism is still under debate. Meteoric smoke particles (MSPs) at mesospheric heights are a strong candidate for explaining polar winter echoes but no direct confirmation of their presence has been made yet.

The ongoing sounding rocket project PMWE led by IAP aims at measuring densities of all dusty plasma constituents including MSPs. Two sounding rockets will carry several Meteor Smoke Particle Detectors (MSPDs), each composed of a central spherical electrode collecting the MSPs, shielded by two concentric and electrically biased grids repelling the ambient ions and electrons. However, understanding the photoelectron current from the electrode induced by the solar UV illumination is critical for quantifying the measurements. The presented research addresses this aspect in two distinct, yet complementary, ways: modeling and calibration.

A detailed model of the MSPD photocurrent was created based on the expected solar UV flux, the atmospheric UV absorption as a function of height, the photoelectic yield of the material coating the MSPD as a function of wavelength, the index of refraction of these materials as a function of wavelength and the angle of incidence of the illumination onto the MSPD. Due to its complex structure, extensive ray-tracing calculations were conducted to obtain the illumination's angle of incidence onto the central electrode and shielding grids for various orientation of the MSPD with respect to the Sun. Results of the modeled photocurrent at different heights are presented in this presentation.

An experimental setup for the calibration of the MSPD photo-current includes a vacuum chamber to simulate the flight condition and a UV light-sources (i.e., a Deuterium lamp whose wavelengths range spans from 115 to 165 nm).

In this paper we present details of the modeling and laboratory calibrations, and discuss the results and their implications on the MSP measurements.

[A-092]

LAUNCH CAMPAIGN OF THE HYBRID SOUNDING ROCKET HEROS

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Due to its inherent safety and easy handling, hybrid rocket propulsion offers a wide bandwidth of application. Scientific progress in hybrid propulsion facilitated the usage of this type of propulsion system as an alternative to the classical liquid and solid propellant based rocket motors. Especially for students, the low cost and simple availability of suitable propellants in hybrid rocket engines combined with a high achievable performance is an advantage.

The so called STERN program (Studentische Experimentalraketen) was initiated in 2012 by the DLR Space Administration with funding from the German Federal Ministry for Economic Affairs and Energy (BMWI) to encourage students to design their own rocket system. During the project, teams from multiple universities developed concepts which were reviewed by experts from DLR.

From the university of Stuttgart, the student team "Hybrid Engine Development" (HyEnD) participated in this program. After two demonstrator launches and various engine tests, the first full scale launch took place at Esrange (European Space and Sounding Rocket Range), Sweden in October 2015. Unfortunately, the flight of the "Hybrid Experimental Rocket Stuttgart 1" (HEROS 1) ended prematurely due to an engine malfunction. One year later, another attempt was taken with the rockets HEROS 2 and HEROS 3. The third full scale rocket HEROS 3 broke the world altitude record for hybrid student rockets and the European altitude record for sounding rockets in general during its nominal flight to an altitude of 32.3 km above ground level. Telemetry data was transmitted over the whole flight and additional data for post flight analysis could be recovered afterwards.

HEROS' propulsion system utilizes paraffin based fuel and self-pressurized nitrous oxide as oxidizer. These propellants are not affected by export restrictions, which simplifies shipping to launch site. For flight, the oxidizer is stored in a CFRP-aluminium tank, which is connected to the engine via a pyrotechnically activated valve. To provide telemetry data, an electronics module is part of the rocket. This module also triggers the two-stage parachute recovery system. A lightweight structure, mainly build out of CFRP, enhances overall performance. Ground support equipment for oxidizer temperature regulation and loading as well as a camera system complete the setup necessary for this hybrid sounding rocket launch.

With the successful launch of HEROS 3 the general potential of hybrid powered sounding rockets has been demonstrated. This result may lead to further developments in the field of hybrid sounding rockets in Europe. Additionally, other student teams will be encouraged to break the altitude record set by HyEnD and therefore increase their effort even more.

[A-98]

PNEUMATIC REENTRY VEHICLE - EVALUATION OF TRANSPORT SYSTEM FOR RETURN TO EARTH

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Sounding rockets are popular mean to rise scientific payloads high above ground, up to the edge of space. During ballistic flight is possible to collect a lot of scientific data as well as to catch air samples. But safe return to Earth is risky and costly. Payload has to be decelerated, typically by small parachute and has to land suspended beneath bigger parachute canopy. Unfortunately payload with opened parachute canopy is very prone to wind blows and its point of landing cannot be accurate determined. So, rather sophisticated telemetry with radar should be used to track payload during descending and it is necessary to use helicopter with crew for pick up payload after landing. Such circumstances prevent use of sounding rocket in areas of special interest in remote parts of Earth because of luck of sophisticated telemetry. Pneumatic reentry vehicle can solve a lot of problems associated with return to Earth and can lower costs of recovery. Authors invented and initially evaluated pneumatic reentry vehicle for 20 kg payload. Special triangle planform of vehicle airframe allows to build vehicle from planar parts of textiles with reinforcements. Such design allows also for zig-zag folding in one direction of outer skin of vehicle fuselage. By folding we can lower diameter of vehicle to diameter of the rocket and by this means not to increase total drag of rocket. At altitude vehicle is filled by gas to obtain aerodynamic shape of airframe. Two steering aerodynamic surfaces are also deployed to allow maneuvering during descent, so vehicle can follow flight path to predetermined location for easy pick up after landing. Landing on water, snow and ice were evaluated also. Support of parachute system for terminal landing and landing on wheels were also analyzed. Proposition of use of pneumatic vehicles for recovery of other stages of sounding rocket was also analyzed, especially in the aspects of pollution of natural environment by debris of rocket's particular stages.

[A-070]

RECENT AND FUTURE NORWEGIAN SOUNDING ROCKET PROJECTS CONDUCTED BY ANDØYA SPACE CENTER

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During the last couple of decades several Norwegian sounding rocket payloads have been launched from Andøya and Svalbard, where Andøya Space Center(ASC) have been responsible for project management, integration and qualification. The missions were either financed financed by the 6^{th} EU Frame Program or through shared funding by the Norwegian Research Council and the Norwegian Space Center. All payloads have been based on the well-proven Hotel Payload configuration. A standardized solution, both mechanically and electronically, with good possibilities for adaptation to a wide variety of scientific needs. Both one and two stage configurations have been flown.

In the summer of 2016 the Improved Malemute Qualification/MaxiDusty mission was conducted from Andøya Space Center as a cooperation between Andoya Space Center and DLR Moraba. The mission had two main objectives; qualifying the Improved Malemute rocket engine for scientific use as well as delivering the two scientific payloads, Maxi Dusty 1 and Maxi Dusty 1b into Middle Atmosphere. Both objectives were reached with great success.

Currently two additional Hotel Payloads are under development. Nucleus and ICI-5. The Nucleus payload is built for Nammo and are going to fly on the test flight of the Nucleus hybrid rocket engine, scheduled for launch September 2017. The ICI-5 payload, with PI Jøran Moen from the University of Oslo, is going to participate in the Grand Challenge as one of the vehicles launched from Svalbard.

The present talk outlines the technical challenges and solutions of the payloads and motor configurations for the mentioned projects.

LIFE AND PHYSICAL SCIENCES 3

THURSDAY 15 JUNE, AFTERNOON SESSION – PART 1

CHAIR: A.VERGA

Plenary Invited Lecture

[A-153]

IN SITU X-RAY STUDIES OF METAL ALLOY SOLIDIFICATION IN MICROGRAVITY CONDITIONS – THE XRMON PROJECT

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The performance of structural materials is commonly associated with the solidification microstructures, which are strongly dependent of gravity effects, in particular thermosolutal convection and solid phase buoyancy. Experimentation in a microgravity environment is a unique way to suppress these effects and to provide benchmark data for testing current theories of grain and microstructure formation. Since 2004, the European Space Agency has been supporting investigation of these effects by promoting in situ X-ray characterization of the solidification of aluminium alloys under terrestrial conditions and on microgravity platforms (sounding rocket and parabolic flights).

This contribution presents an overview of results obtained on solidification of Al-Cu alloy so far, focussing on three different topics (ground reference experiments were completed in all cases and a comparative study of experiments carried out on earth and in microgravity environment was performed):

- The first ever microgravity experiment on solidification with in situ monitoring of metal alloys, which was performed on board a sounding rocket (MASER-12, 2012) and devoted to the columnar solidification. The impact of gravity on dendrite fragmentation during columnar growth was enlightened in particular.
- A solidification experiment in spatially isothermal conditions, which was dedicated to the investigation of equiaxed solidification and carried out on board a sounding rocket (MASER-13, 2015). The absence of equiaxed grain movement during the early stages of microgravity experiment enable us to obtain benchmark data for computational modelling of equiaxed metal alloy solidification and isolate shrinkage effects towards the end of solidification.
- In addition, solidification experiments have been performed on board parabolic flights, where the effects of varying gravity level have been studied. An unexpected change in grain structure (from columnar to equiaxed) was observed during each parabola, due to the change of the hydrostatic pressure associated to the gravity level variation.

We review here the technical and scientific progress to date, and outline future perspectives.

[A-025]

REXUS22 GRAB: ASSESSMENT OF THE ADHESIVE PROPERTIES OF GECKO-INSPIRED MATERIALS UNDER SPACE-LIKE CONDITIONS

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Proper functioning satellites are essential to most modern technologies. However, an increasing number of space debris in specific functional orbits poses a risk to the intended operation of spacecraft. To mitigate the risk of satellite/debris collision events it is necessary to actively remove high-risk objects such as non-functional satellites or spent upper stages from corresponding orbits. This procedure is called active debris removal (ADR) and is meant to be performed by robotic spacecraft.

An ADR system needs to be capable of approaching, capturing, detumbling and deorbiting worthwhile debris. In order to achieve contact with targeted objects, gecko-inspired adhesive materials can be utilised. In comparison to other ADR concepts, the advantages of using gecko adhesives are, among others, reusability and the dry adhesion without leaving a residue. The adhesive force of gecko materials is made possible by their fungiform microstructures, which adhere to various surfaces, materials and geometries by means of van der Waals forces. Currently, the TLR of gecko adhesive related application in aerospace industry is low.

To address this issue, the Gecko-Related-Adhesive-testBundles (GRAB) experiment is scheduled to be launched on board the REXUS 22 sounding rocket in March 2017. GRAB is exposing said gecko adhesives to a near space environment, characterised by microgravity, low pressure, temperature fluctuations and radiation, while measuring the adhesive forces. The experiment's main objective is to observe how the mentioned materials behave in comparison to a laboratory environment. The GRAB team is part of the ExperimentalRaumfahrt-InteressenGemeinschaft e.V. (ERIG) located in Brunswick, Germany. The ERIG is an astronautics-oriented association of interdisciplinary skilled students, who design and build sounding rockets and perform numerous space-related experiments.

The proposed paper will introduce the experiment setup and cover the data, which will be collected during flight. Furthermore, the results of conventional material tests on after-flight gecko materials will be presented. The paper will also include a detailed description of the test mechanism and a thorough experiment data analysis. Consequently, this is going to verify gecko adhesives for space-related applications and improve the design of ADR gripper systems.

[A-150]

THE XRMON-DIFF2 DIFFUSION EXPERIMENT ON MAXUS 9 MISSION

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The XRMON-Diff2 experiment is a re-flight of the XRMON-Diff experiment which was flown on MAXUS 8 sounding rocket in 2010. The experiment objective is to observe diffusion in materials, with real time in-situ X-ray observation of the diffusion process. The experiment is performed in the scope of the ESA Material Sciences MAP project

The experiment system used in MAXUS 8 has been updated to house two new shear-cell furnaces, replacing the three long capillary furnaces processed on MAXUS 8. This has led to a thorough update of the module hardware and control system.

The shear cell furnaces, developed by the DLR Insitute of Material Physics in Cologne, each contain four experiment samples, forming three sample couples after shearing. The experiment accommodates one high temperature shear cell operated at 1560°C containing AlTi samples and one shear cell operated at 1200°C containing SiGe samples. An evacuated experiment enclosure is designed to provide a low pressure environment to the experiment during processing.

This paper will report on the technical realization of the experiment and its flight timeline on MAXUS 9 sounding rocket mission.

[A-021]

U-PHOS EXPERIMENT: THERMAL RESPONSE OF A LARGE DIAMETER PULSATING HEAT PIPE ON BOARD REXUS 22 ROCKET

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A Pulsating Heat Pipe (PHP) is tested on board REXUS 22 sounding rocket in order to obtain data over a relatively long milli-gravity period (120s). The device is an aluminium tube bent in a serpentine staggered configuration, closed in a single loop and partially filled with FC-72. It has an inner diameter of 3mm, greater than the capillary threshold for which there is a difference in fluid behaviour, in horizontal position: for a smaller diameter the serpentine works as a classic PHP, with the typical alternance between slugs and plugs and the heat exchange triggered by thermally driven self-sustained oscillations of the working fluid; for a larger one, instead, the heat pipe does not work.

This characteristical behaviour is driven by the balance between buoyancy forces and surface tension in the working fluid. Due to gravity, with a large diameter, the buoyancy forces overcome the surface tension and the working fluid stratifies, thus impairing the PHP's capacity to efficiently exchange heat. Then, the idea to test the PHP in a reduced gravity environment: as the gravity decreases, the buoyancy forces become less and less intense and it is possible to recreate the pulsating behaviour even for larger diameters. The possibility to build bigger PHPs, with increased heat transfer rates and reduced overall thermal resistances, could be an interesting step forward in the fast developing space industry, always craving for greater performances at a reduced weight and cost.

The experiment is the natural improvement of the PHOS project, launched on REXUS 18 but only partially successful due to a failure in the despin system of the rocket. All of the components have been improved, especially the data acquiring system, now employing 24 Fiber Bragg Grating optical sensors for a more accurate temperature detection, and the heat sink, now composed by a combination of paraffin wax and metal foams for an enhanced thermal conductivity. The thermal response of the device is given under a constant heat power supply at the evaporator.

[A-069]

THERMALLY INDUCED MATERIAL FLOW IN A TWO-DIMENSIONAL LIQUID CRYSTAL FILM

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Liquid crystals (LC) feature properties of fluids (e.g. fluidity) as well as properties of solids (e.g. orientational and partial positional order). In addition to their application in everyday life, LCs show a rich variety of properties that are interesting from a point of view of fundamental physics. For example, smectic LC films can serve as model systems for two-dimensional fluids. These films can have lateral extensions of several millimeters at submicrometer thicknesses. Their aspect ratio may exceed 10^6. In our study, we investigate thermally induced flow in freely suspended liquid crystal films. In detail, we focus on thermodiffusion and thermally driven convection in the film plane.

While the influence of gravity on the shape of such films is negligible, it is hardly possible to avoid the effect of airflow on films under thermal gradients under conditions of normal gravity. In order to avoid any such influences (e.g. air buoyancy driven transport in the film), the experiment was performed during a 6 min microgravity phase of a TEXUS suborbital rocket flight launched in ESRANGE near Kiruna.

We used the microgravity phase to draw a smectic film that was in contact with two tempered elements. This allowed us to apply thermogradients up to 10 K/mm within the film plane at an ambient temperature of 50°C. The effect of the thermogradient on the LC film was recorded in reflection with a CCD camera. Advective flow in the film was identified by the observation of the displacement of smectic C Schlieren structures in polarized light.

We demonstrate that temperature gradients up to 8 K/mm induce flow from the warm post to the cold one. This is accompanied by a material redistribution with an exess at the cold post.

The reason is a thermodiffusive flow triggered by the temperature-sustained surface tension gradient. At high temperature gradients of around 10 K/mm, the laminar flow is masked by a convective motion with its origin at the warm post. After reset of the thermogradient the collected smectic material at the former cold post is repelled into the film again. We discuss our experimental results and compare them to earlier experiments by Godfrey et al [1], who evacuated the experiment chamber to avoid air convection under normal gravity.

The OASIS project is funded by NASA Grant NNX-13AQ81G. OASIS-Co is supported by the German Aerospace Center (DLR) within project 50WM1430.

[1] M. I. Godfrey, and D. H. van Winkle, Phys. Rev. E 54, 3752 (1996).

TECHNOLOGY AND INFRASTRUCTURES FOR SOUNDING ROCKETS 4

THURSDAY 15 JUNE, AFTERNOON SESSION – PART 1

CHAIR: D.KRAUSE

[A-008]

DESIGN OF HYBRID LIGHTWEIGHT FINS FOR SOUNDING ROCKETS

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The structural mass of sounding rockets is a critical factor as it influences the range, the possible payload mass and with it the options for scientific experiments. Hence investigations into a new fin design are driven by the requirement to reduce weight and increase the maximum load limit at the same time. To fulfill these objectives, a hybrid design that combines metallic and composite materials is chosen. Carbon Fibre Reinforced Plastic (CFRP) is a suitable material for high-performance composites due to its increased strength to weight ratio. It is applied in the sandwich structure of the fin, which is made of thin CFRP facings and a foam core. The interface between the sandwich structure and the metallic attachment to the rocket is realized by an adhesive sealing. The fins presented in this paper are designed for the sounding rocket Improved Malamute. This rocket is stabilized by a three fin configuration and was first launched in June 2016 from the Andøya Space Center. The trajectory of the rocket is characterized by intense pressure loads that result in a bending moment, M = 4.3 kNm, at the root cord of the fins. Furthermore, the thermal loads are increased as a result of the high flight velocities in a dense atmosphere. Thus, the thermal protection system is a critical part of the fin design. Within this topic the development of a cork ablator and preceding tests are discussed. This paper explains the complete development process of the CFRP fins from the concept phase to the design, numerical simulations, the fabrication, as well as the qualification tests on ground and preliminary results of the test flight. The new fin design results in a weight reduction of 25% compared to the metallic fins. The qualification test proved that the structure can withstand more than 1.5 times the nominal pressure load without lasting deformations. These results confirm the achievement of objectives and demonstrate the high potential of composite materials for space components.

[A-102]

ON THE CALIBRATION OF PLASMA PROBES ON THE MAXIDUSTY MESOSPHERIC ROCKET PAYLOADS

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Plasma probes on rockets are essential tools in investigations of the conditions in the Earth's mesosphere. However, the calibration of such probes in the NLC cloud regions is normally difficult, partly because electron and ion collision lengths change much and are often comparable to probe sizes , and also since the integrated electron density below the clouds and the resulting Faraday rotation can be small with considerable uncertainties.

In the present work we apply the method proposed by Havnes et al (Rev.Sci.Instr **82**, 074503, 2011), where a comparison between variations in a plasma probe and dust impact probe currents is used to calibrate the plasma probe. We focus on the plasma and dust observation by two MAXIDUSTY rocket payloads MXD-1 and MXD-1B, launched in the summer 2016 and compare the plasma probe cross sections found by the above method, with the cross sections found by theoretical estimates and Faraday rotation measurements.

[A-111]

LOW COST NAVIGATIONAL DATA RECORDING PAYLOAD FOR SERA SOUNDING ROCKETS

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The PERSEUS project (Projet Etudiant de Recherche Spatiale Européen Universitaire et Scientifique) is an initiative of CNES (Centre National d'Études Spatiales) to promote innovative technical solutions in the aerospace domain with industrial and educational applications, realized by university students. One of the projects under PERSEUS is SERA (Supersonic Experimental Rocket ARES), whose objective is to provide a platform to test and validate other technologies developed in the frame of PERSEUS, through a supersonic flight.

VISTA (Vibrations Inherent System for Tracking and Analysis) is a payload provided by an international team of students studying at the LTU (Luleå Tekniska Universitet) in Kiruna, Sweden. The payload will be carried by the SERA-3 rocket, as the third iteration of the SERA project, and is scheduled to be launched in April 2017 from Esrange Space Center in Kiruna, Sweden.

VISTA's main objective is to record an accurate trajectory and vibrational data of the SERA-3 sounding rocket throughout its flight, for use as a reference in future SERA missions. This will be done by gathering raw GPS (Global Positioning System) and IMU (Inertial Measurement Unit) data during flight. The collected data will be stored on a memory card to be retrieved after the rocket has landed. Once the data is read from the memory card, it will be post processed on the ground. The first step of the post processing will be to decode the GPS data into its NMEA 0183 form (National Marine Electronics Association). The second step will be to run the NMEA and IMU data through a Kalman filter to obtain a precise trajectory and vibrational data of the flight.

Furthermore, commercial GPS devices without the COCOM (Coordinating Committee for Multilateral Export Controls) limits applied are often too expensive for a student-targeted project with a limited budget. VISTA's implementation tackles that obstacle by using cheap, off-the-shelf components and an open source design. Moreover, instead of decoding the GPS signal in realtime, using the post processing method reduces the system complexity and points of failure. In addition to providing an accurate trajectory, success of the VISTA mission would also lay groundwork for subsequent experiments with its GPS solution, since previous SERA missions failed at providing a working GPS implementation.

Life and Physical Sciences 4

Thursday 15 June, Afternoon session – part 2

Chair: M.Egli

[A-029]

MULTIPLE EQUIAXED DENDRITE INTERACTION INVESTIGATED ON MASER-13

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The nucleation, growth and interaction of equiaxed dendritic solidification structures were investigated experimentally, and by microstructure modelling. Experimentally, this is achieved by solidifying an organic transparent alloy Neoppentylglycol-30.0wt.-%(d)Camphor, which crystallizes with similar dendritic morphology as metallic alloys. The experiment was carried out onboard the sounding rocket MASER-13, where convection of the melt and sedimentation of the dendrites is negligible. The experimental conditions (thermal gradient, cooling-rate) were adapted to obtain multiple equiaxed dendritic structures, which then interact via their solutal fields. The structures were observed with two different optical systems to analyze the global and the microscopic features of solidification. Here, we present the experimental results and comparison to a numerical simulation. As one highlight it was found, that the favourable crystallographic orientation of the dendrites deviates from the regular case and causes equiaxed growth with eight instead of six arms. Microstructural phase-field simulations validate this result, where the changed crystallographic orientation is devoted to a significant change in the solid-liquid interface energy anisotropy.

[A-034]

LESSONS LEARNED FROM THE FIRST FLIGHT OF AN ATOM INTERFEROMETER PAYLAOD ON A VSB-30 SOUNDING ROCKET PAYLOAD

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The MAIUS experiment recently demonstrated the first Bose-Einstein Condensates in Space in the challenging environment aboard a two-staged VSB30 sounding rocket.

In order to achieve this ambitious scientific goal the experiment is using various sensitive instruments giving hard requirements on the thermal and mechanical design of the scientific payload. Especially the commercial ultra-high vacuum components used to maintain a pressure of 1E-10 mbar appeared to be sensible to strong vibrations and accelerations.

This paper gives a short summary of the scientific payload design. It focuses on the engineering aspects of the vacuum system, the thermal control system and the sealing of the payload area used to maintain a pressure of 1.2 bar within the scientific payload during the microgravity phase.

In the main part of this paper the environment as hull and air pressure and air temperatures of the scientific payload during the flight will be evaluated. Moreover the performance of the vacuum system and the thermal control system during the environmental tests as well as during flight will be discussed. Furthermore important lessons learned from this unique mission are presented. The paper closes with an outlook to future atom interferometry payloads on sounding rockets.

[A-117]

SOUNDING ROCKET MISSION MAIUS-1: CREATING THE FIRST BOSE-EINSTEIN CONDENSATE IN SPACE

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On January 23rd 2017 MAIUS-1 was launched from Esrange in Sweden. Onboard it carried an atomoptical experiment aimed at creating the first Bose-Einstein condensates in space and using this quantum degenerate matter as a source for matterwave interferometry. Here we will present the first results of the experiments during the flight, including the first creation of a Bose-Einstein Condensate in Space. The successful operation of the atom-chip based BEC source marks a major advancement in the effort of performing matter wave interferometry on space vehicles. Due to their small initial size and low expansion rates BECs are the ideal source for such an interferometric measurement in space.

MAIUS-1 opens a new path towards space born inertial sensing employing atom interferometers with high accuracy and unprecedented sensitivity. In the recent past several missions were proposed ranging from a test of the universality of free fall using a dual-species atom interferometer to gravimetry for earth observation. There are two follow-up missions planned which will include dual-species atom interferometry using Rubidium-87 and Potassium-41. The findings of these missions will also contribute to the NASA CAL project and BECCAL, thought to be a joint endeavor of NASA and DLR in the realm of experiments with BECs in space.

[A-035]

COLUMNAR-TO-EQUIAXED TRANSITION IN THE TRANSPARENT ALLOY SYSTEM NPG-DC FOR DIFFERENT GRAVITY LEVELS - THE EXPERIMENT "TRACE-3"

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The experiment TRACE-3 (TRansparent Alloys in Columnar Equiaxed solidification - 3) was carried out onboard the sounding rocket TEXUS-51 in low-gravity environment, as well as lateron in 1g and hyper-gravity environment on a centrifuge.

The aim of these experiments is the investigation of dendritic growth and the transition from columnar to equiaxed (CET) solidification in the transparent organic alloy system Neopentylglycol (NPG)-(D)Camphor (DC). The transparency of this alloy enables an in-situ observation of the solidification behaviour by using two optical cameras.

Here we present experimental results of the TRACE-3 microgravity experiment and of the 1g ground reference experiment. Relevant parameters like thermal gradient, solidification velocity and undercooling within the bulk liquid and at the columnar dendritic tips are determined. From the analysis of the images and the thermal data also the critical parameters for the transition from columnar to equiaxed solidification will be given. Additionally, experiments on a centrifuge with g-level up to 10g were performed. It is found that in this hyper-g environment forced melt convection and increased sedimentation of equiaxed dendrites alter the nature of the columnar-to equiaxed transition.

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Thursday 15 June, Afternoon session – part 2

Chair: K. Blix

[A-116]

RACOS - A COLD GAS RATE CONTROL SYSTEM ON BOARD OF REXUS 22

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RaCoS (Rate Control System) is a payload part of REXUS 22 which launched in March 2017 at Esrange Space Center. The experiment's purpose was to reduce and control the angular rate of the REXUS sounding rocket in the roll axis by using a cold gas system propelled by nitrogen. In order to achieve the experiment's objective, the angular rate of the roll axis is measured and used by the control algorithm, which calculates the opening times of the valves. The control algorithm was designed as a three-point controller with a shutdown prediction for compensating the system response time. To react to various scenarios, the predictor has the ability to adapt to different system behaviours, especially different masses or thrust.

Unlike most existing systems, RaCoS is lightweight and was inexpensive to build. This was achieved by using commercial off-the-shelf components, which also includes industrial, but non-space grade solenoid valves, common pressure hoses and carburetor jets instead of laval nozzles. In extension, RaCoS aims to help to improve the milli-gravity environment of the REXUS rocket which many experiments rely on.

The system design section describes the underlying theory used for dimensioning and choosing the parts included in the experiment and their mechanical integration. This contains the criteria for the tank, the selection of the solenoid valves, as well as the MEMS IMUs and the calculations for the size of the nozzles.

The experience gained through this experiment will be useful for further university projects. In the future, the system could be extended to the other two axes for full attitude manoeuvrability.

[A-104]

OVERVIEW OF THE DIPOLE INFLATABLE ANTENNA EXPERIMENT (DIANE) WITHIN THE REXUS 21 MISSION

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Inflatable structures attract for its unique characteristics. Low mass and superior volume packaging efficiency – those are not all, but the most significant advantages of such structures. Extremely light constructions can be fabricated out of thin films or various airtight textiles. Being a promising technology for future space applications, inflatable structures generally is a constantly developing theme, huge subject of discussions with lots of opened questions yet. As such constructions can be inflatable antennas having a huge potential in this field. Inflatable antennas can have wide range of application, beginning with ground penetrating radar used during space body flyover and ending with plasma probes and solar orbiter missions.

Today's tiny satellites use mechanical antenna stripes, which after deployment bring the satellite itself to excessive dynamical vibrations. Forces, moments and vibration profiles of the huge mechanical antennas for space can be estimated with mechanical laws on Earth. Inflatable structures, in their turn, can cause unexpected dynamics during inflation. It is possible to simulate the inflating process on computer, but verification of the simulation of the real deployment process it is not reasonable due to the earth gravity. The rocket parabolic flight during the REXUS 21 campaign provides a relative simple opportunity to conduct and observe this verification in milligravity environment.

For this reason, the Dipole Inflatable Antenna Experiment (DIANE) will be conducted within the REXUS 21 campaign. Being a successor of the InTex experiment held on BEXUS 21 mission, DIANE experiment is focused on developing of a first 7m long inflatable dipole antenna for application on miniaturized satellites like a CubeSat. The deployment process of the antenna, stowed and stored in volume of 0.2dm³ within a CubeSat, is being recorded by two cameras for future analysis and comparison with computer simulated model. It helps us to understand the dynamical behavior of gas inflated structures and scale it for other applications.

The paper also describes the process of fabrication of antenna structure out of thin Nylon fabric coated with Thermoplastic polyurethane (TPU). The mechanical and electrical properties of selected materials, the antenna itself, supporting structure design and tests are covered as well. Almost all inflatable constructions are subject of structure stability and pressure loss issues. For this experiment, no rigidizing technology was implemented due to the focus on the dynamic inflation behavior and the short experiment duration. However, suitable technologies for rigidizing are proposed for further experiments and applications.

[A-110]

HORIZON ACQUISITION FOR ATTITUDE DETERMINATION USING IMAGE PROCESSING ALGORITHMS – RESULTS OF PATHOS ON REXUS 20

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Position-vector Acquisition Through Horizon Observation System (PATHOS) was a technical presentation with the aim of proving the functionality of a new concept for an earth sensor used in attitude determination under space conditions as well as a miniaturization of the predecessor project HORACE in the form of a stand-alone sensor. The experiment processes regular optical data coming from a camera to detect Earth's horizon and use it to calculate a 2D vector to the centre of the Earth, thus offering information on the spacecraft's attitude.

PATHOS uses image data from a regular camera sensitive to the visible spectrum of light. This carries certain requirements for the software component, which must be able to cope with all the likely disturbances in space such as direct sunlight, lens flares and atmospheric influences. All these interferences have to be overcome in order for the system to be usable as an emergency system in satellites which already carry any type of payload camera. PATHOS employs three main steps for calculating the attitude data: a Threshold Filter which transforms grey-scale image data received form the camera into black and white or binary data, a Topological Search which selects the horizon line out of all the possible ones contained in one picture and a Least Square Method to calculate the 2D vector to the Earth's centre point. The algorithm also makes use of the Divide and Conquer approach in order to eliminate some of the interference named above.

The opportunity to be accommodated on a REXUS rocket provided a number of advantages for testing the PATHOS system. The flight offered all important test scenarios, from high spin rates during the rockets ascend to uncontrolled tumbling and low spin rates during the descend and the reached altitude was high enough for testing the experiment in real space-like conditions. The accommodation possibilities of a REXUS rocket also provided the chance to test two independent PATHOS systems at the same time. During its flight on REXUS 20, PATHOS collected enough video data with the correlated algorithm results to provide reliable data about the system's behaviour during the different stages of the flight as well as qualitative and quantitative proof regarding the robustness of the horizon sensor system.

All of PATHOS' subsystems performed nominally throughout all the tests, the countdown and flight. The flight data (video data and corresponding on-board processing results) prove that the system is fast enough and reliable enough to be used under space conditions with a frame rate of approximately 12 frames per second, as well as efficient enough regarding power requirements, size and mass, thus being usable in small satellites.

Valuable technical knowledge was also gained alongside scientific data throughout the duration of the PATHOS project, such as technical design and general requirements of a REXUS experiment.

[A-167]

THE IMAGE SYSTEM OF SOUNDING ROCKET SEVE2

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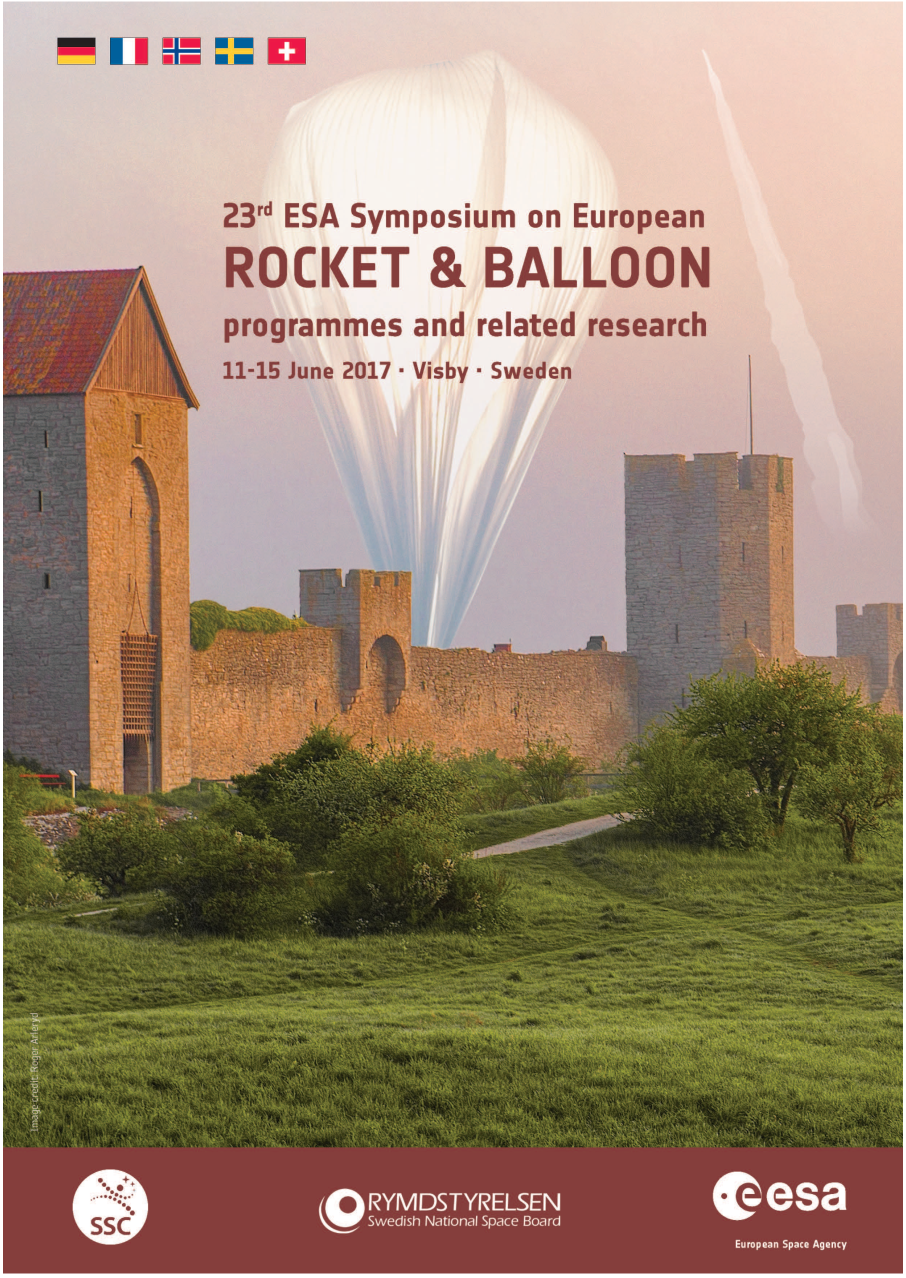
This paper introduces the image system for the second sounding rocket of Chinese Space Environment Vertical Exploration Project (SEVE2), which has been successfully launched in April 27, 2016.

The image system is designed to monitor nose ejection, motor separation, and boom deployment, with 4 commercial cameras to record image, and 1 electret microphone to record sound.For the SEVE2 rocket is not recoverable， all datas are transmitted to ground before the re-entry with the limited downlink data band，900kbps. How to design the system within the limited bandwith is an important problem.

To reduce the downlink data, the image compression ration is nearly 120, using JPEG2000 algorithm implemented with the chip ADV212. And, Audio is compressed by CMX649 using the CVSD algorithm. The system is designed with a FPGA architecture.

In no-action time, images of 4 cameras are recorded at 1fps. And, during the action time, the special cameral recording frame rate is changed to 25 fps according to the experiment timeline.All the image datas and audio datas, are buffed into a FIFO, and then downlink serially.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