INTERNATIONAL SPACE STATION: STUDY OF NEAR-SURFACE ENVIRONMENT

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Main hindrances to use ISS for geophysical experiments

- High surface potential
- High noise level in near-surface zone
1. Study of super–large body interaction with space plasma: bow shock and wake formation conditions at ISS flow by ionospheric plasma; plasma-wave disturbances formation mechanism analysis in ISS environment, including active experiments and electromagnetic waves and accelerated particles flows generation.

2. Conditions and possibilities of geophysical experiments onboard ISS: study of electromagnetic noise spectral and spatial distribution around ISS; development of methodology for terragenic disturbances selection provoked by natural and man-made hazards at the ISS noisy background.

OBSTANOVKA experiment onboard Russian segment of ISS

Co-PI of magnetic field meter
IKI RAS
Space Research Institute

Co-PI of radio frequency analyser
IKI BAS

PI of electrons spectrograph
Sussex University
Sheffield University

PI of electromagnetic fields meter
Eotvos University

Co-PI of data collection unit, BSTM and GSE
KFKI RMKI

PI of Langmuir probe
IKI BAS
STIL

Co-PI of data collection unit
SRC PAS

PI of wave probe
LCISR

Co-PI of radio frequency analyzer and GSE

Co-PI of potential monitor
OBSTANOVKA experiment onboard ISS
OBSTANOVKA tool kit setting
Boom 1 in stowed state
Boom 2 in stowed state
The PWC composition and experiment participants

<table>
<thead>
<tr>
<th>Unit</th>
<th>Responsible Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined wave sensor CWS-1, CWS-2</td>
<td>LC ISR, Ukraine</td>
</tr>
<tr>
<td>Fluxgate magnetometer DFM-1</td>
<td>IKI RAS, Russia</td>
</tr>
<tr>
<td>Fluxgate magnetometer DFM-2</td>
<td>LC ISR, Ukraine</td>
</tr>
<tr>
<td>Langmuir probes LP-1, LP-2</td>
<td>STIL BAS, Bulgaria</td>
</tr>
<tr>
<td>Spacecraft potential monitor DP-1, DP-2</td>
<td>ISR BAS, Bulgaria</td>
</tr>
<tr>
<td>Correlating Electron and ion Spectrograph, CORES</td>
<td>Sussex University, United Kingdom</td>
</tr>
<tr>
<td>Radio Frequency Analyzer RFA</td>
<td>SRC PAS, Poland; IRF, Sweden</td>
</tr>
<tr>
<td>Signal Analyzer and Sampler SAS3</td>
<td>Eötvös University, Hungary</td>
</tr>
<tr>
<td>Data Acquisition and Control Unit DACU</td>
<td>KFKI RMKI, Hungary</td>
</tr>
<tr>
<td>Block of Storage of TeleMetry BSTM (inside ISS)</td>
<td>KFKI RMKI, Hungary</td>
</tr>
<tr>
<td>Automatic System of ThermoRegulation ASOTR</td>
<td>IKI RAS, Russia</td>
</tr>
<tr>
<td>Booms with sensors</td>
<td>RSK “Energia”, Russia</td>
</tr>
</tbody>
</table>
PWS Instrument Set
Structure of DACU Unit

DACU Power 28V

BSTM

Ethernet

PC/104 Bus

Outside

DACU1

Galvanic Insulation

Power Supply

CPU

300 MHz

RS-422 Interface

16-bit A/D Converter

Power Control

Analogue Signals from Experiments

Analogue Signals for Experiments

Power Supply for Experiments

DP-1

LP-1

Bac, Jac, Uac, Udc, 11 Sign. of DFM1

CWZ-WP

DP-1

LP-1

SAS3

DFM1

Power Control

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CWZ-WP

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LP-1

SAS3

DFM1

Power Control

Outside

Ethernet

PC/104 Bus

Outside

DACU1
### BSTM and DACU units general parameters

<table>
<thead>
<tr>
<th></th>
<th>Size, mm</th>
<th>Weight, kg</th>
<th>Power, W</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSTM</td>
<td>228x170x230</td>
<td>4.67</td>
<td>25</td>
</tr>
<tr>
<td>DACU1</td>
<td>147x176x162</td>
<td>3.1</td>
<td>10</td>
</tr>
<tr>
<td>DACU2</td>
<td>147x176x162</td>
<td>3.1</td>
<td>10</td>
</tr>
</tbody>
</table>
DACU prototype
CORES functional block diagram

Electrons

Electron Optics → MCP Electron Detector → PreAmps → FPGA → DPU → TM/TC I/F

HV

DC/DC

Power

TM/TC

TM

TC
### CORES main characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Functional</strong></td>
<td></td>
</tr>
<tr>
<td>Electron Energy Range, eV</td>
<td>$10^1$ to $10^4$</td>
</tr>
<tr>
<td>Frequency Ranges, Hz</td>
<td>HF:0-10^7; VLF:0-10^4; ELF:0-150</td>
</tr>
<tr>
<td>Frequency Resolution, % of range</td>
<td>3</td>
</tr>
<tr>
<td>Energy Resolution, % of each enter</td>
<td>50</td>
</tr>
<tr>
<td><strong>Operational</strong></td>
<td></td>
</tr>
<tr>
<td>Discrete Commands</td>
<td>1 Command [ON/OFF]</td>
</tr>
<tr>
<td>TM Rates (Mode dependant)</td>
<td>100 bps to 100 kbps</td>
</tr>
<tr>
<td><strong>General</strong></td>
<td></td>
</tr>
<tr>
<td>Weight, kg</td>
<td>1.1</td>
</tr>
<tr>
<td>Power, W</td>
<td>2(+/− 0.2)</td>
</tr>
<tr>
<td>Voltage, V</td>
<td>27.0 (+/− 4.0)</td>
</tr>
<tr>
<td>Dimension, mm</td>
<td>100 x 100 x 150</td>
</tr>
</tbody>
</table>
PARTICLE ANALYZER CORES
The CWS1, CWS2 operation block diagram

- **B-sensor**
- **PreAmp B**
  - Out. “B”
  - Cal. Control B
- **Calibr. B**
- **I-sensor**
- **PreAmp I**
  - Out. “I”
  - Cal. Control I
  - Calibr. Sign
- **Calibr. E,I**
- **E-sensor**
- **PreAmp E**
  - Out. “E”
- **T-sensor**
- **Linear Regul.**
  - Out. “T”
  - Power
Combined wave sensor (CWS)
## CWS1, CWS2 Basic Technical Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency band of all signals, Hz</td>
<td>0.1 … 40000</td>
</tr>
<tr>
<td>Noise levels at frequency 1 kHz for:</td>
<td></td>
</tr>
<tr>
<td>Magnetic induction channel, nT/√Hz</td>
<td>≤ 0.1</td>
</tr>
<tr>
<td>Current density channel, pA/cm²⋅√Hz</td>
<td>≤ 0.1</td>
</tr>
<tr>
<td>Electric potential channel, nV/√Hz</td>
<td>≤ 20</td>
</tr>
<tr>
<td>Transfer factor:</td>
<td></td>
</tr>
<tr>
<td>Magnetic induction channel, V/T (flat part)</td>
<td>$10^8$</td>
</tr>
<tr>
<td>Current density channel, V/A (effective surface area 78 cm²)</td>
<td>$10^6$</td>
</tr>
<tr>
<td>Electric potential amplifier gain</td>
<td>10</td>
</tr>
<tr>
<td>Operation temperature range, °C</td>
<td>- 40...+ 70</td>
</tr>
<tr>
<td>Power consumption, W</td>
<td>≤ 0.2</td>
</tr>
<tr>
<td>Overall dimensions, mm</td>
<td></td>
</tr>
<tr>
<td>CWS-PP Sensor</td>
<td>Ø27x300</td>
</tr>
<tr>
<td>CWS-SC unit</td>
<td>50x136x50</td>
</tr>
<tr>
<td>Total weight, kg</td>
<td>0,18</td>
</tr>
</tbody>
</table>
The SAS-3 operation block diagram

- **Power Supply Unit**
- **Fast Sampler 2Ms/s 128 MB RAM**
- **2 channel Analog Input Slow ADC**
- **Digital Signal Processor Event Detector**
- **Telemetry Interface Ethernet**

- DACU1
- CWS1
- CWS2
- BSTM
## Technical parameters of the SAS3

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measurement bandwidth</strong></td>
<td>1 Hz - 20 kHz (LS) ... 100 kHz (HS)</td>
</tr>
<tr>
<td><strong>Input bandwidth</strong></td>
<td>DC...100 kHz</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td></td>
</tr>
<tr>
<td>on electric component</td>
<td>$5 \times 10^{-7}$ V/mHz$^{1/2}$</td>
</tr>
<tr>
<td></td>
<td>(0.3 $\mu$V/Hz$^{1/2}$)</td>
</tr>
<tr>
<td>on magnetic component</td>
<td>$10^{-2}$ pT/Hz$^{1/2}$</td>
</tr>
<tr>
<td></td>
<td>(0.3 $\mu$V/Hz$^{1/2}$)</td>
</tr>
<tr>
<td><strong>Dynamic range, dB</strong></td>
<td>120</td>
</tr>
<tr>
<td><strong>Power consumption, W</strong></td>
<td>$\leq$ 12</td>
</tr>
<tr>
<td><strong>Supply voltage, V</strong></td>
<td>22-36</td>
</tr>
<tr>
<td><strong>Operating temperature range, °C</strong></td>
<td>-20 - +70</td>
</tr>
<tr>
<td><strong>Mass, g</strong></td>
<td>$\leq$ 1200</td>
</tr>
<tr>
<td><strong>Telemetry connection</strong></td>
<td>10/100 Mbit/s STP-Ethernet</td>
</tr>
<tr>
<td><strong>Modes of operation</strong></td>
<td>waveform (standard or high speed sampling), spectrum, registration of</td>
</tr>
<tr>
<td></td>
<td>electromagnetic events</td>
</tr>
<tr>
<td><strong>High speed sampling (HS)</strong></td>
<td>2 Mspsp</td>
</tr>
<tr>
<td><strong>Internal memory, MB</strong></td>
<td>256</td>
</tr>
<tr>
<td><strong>Buffer size of one measurement</strong></td>
<td>1 MB / 128 MB max. (LS/HS)</td>
</tr>
<tr>
<td><strong>Size, mm</strong></td>
<td>$150 \times 110 \times 100$</td>
</tr>
</tbody>
</table>
Flux gate magnetometer DFM-2 functional diagram

Feedback Circuit

Flux Gate Sensor

PreAmps

Phase Detectors

DC Amps

ADC

CPU

RS-232 Interface

Power

Excitation Circuit

PCU

f

2f
## Basic Technical Specifications of DFM2 (LEMI-012)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement range, nT</td>
<td>&gt; ± 60000</td>
</tr>
<tr>
<td>Resolution, nT</td>
<td>≤ 1</td>
</tr>
<tr>
<td>Axial non-orthogonality (after compensation)</td>
<td>≤ ± 0.2° of arc</td>
</tr>
<tr>
<td>Maximal offset, nT</td>
<td>50</td>
</tr>
<tr>
<td>Zero drift over temperature, nT/°C (after compensation)</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Gain drift over temperature, % of reading /°C</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Power consumption, W</td>
<td>&lt; 0.3</td>
</tr>
<tr>
<td>Overall dimensions, mm and weight, kg</td>
<td>150x90x45, 0.7</td>
</tr>
<tr>
<td>Shockproof, till, g</td>
<td>150</td>
</tr>
</tbody>
</table>
DFM2 - three-component flux-gate magnetometer LEMI-012
CWS and DFM2
DP-PP and DP-VP module functional diagrams
# DP main characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Functional</strong></td>
<td></td>
</tr>
<tr>
<td>Electric potential, V</td>
<td>- 100 ÷ + 100</td>
</tr>
<tr>
<td>Frequency range, Hz</td>
<td>0-250</td>
</tr>
<tr>
<td>Potential Resolution, mV</td>
<td>3.125</td>
</tr>
<tr>
<td><strong>Operational</strong></td>
<td></td>
</tr>
<tr>
<td>Digital Commands</td>
<td>4+2 Commands</td>
</tr>
<tr>
<td>TM Rates (Mode dependant)</td>
<td>0.03 bps to 16 kbps</td>
</tr>
<tr>
<td><strong>General</strong></td>
<td></td>
</tr>
<tr>
<td>Weight DP-PP, g</td>
<td>300±10</td>
</tr>
<tr>
<td>Weight DP-VP, g</td>
<td>725±10</td>
</tr>
<tr>
<td>Power consumption, W</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Voltage supply, V</td>
<td>23.0÷28.0</td>
</tr>
<tr>
<td>Overall dimensions DP-PP, mm</td>
<td>255x100x80</td>
</tr>
<tr>
<td>Overall dimensions DP-VP, mm</td>
<td>150 x 80 x 100</td>
</tr>
</tbody>
</table>
Spacecraft potential monitor DP
Functional diagram of LP unit
# LP main characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Functional</strong></td>
<td></td>
</tr>
<tr>
<td>Current, A</td>
<td>± (5.10^-11 - 5.10^-5)</td>
</tr>
<tr>
<td>Ur Sweep electrode voltage, V</td>
<td>-100 +100</td>
</tr>
<tr>
<td><strong>Operational</strong></td>
<td></td>
</tr>
<tr>
<td>Discrete Commands</td>
<td>6+2 Commands</td>
</tr>
<tr>
<td>TM Rates (Mode dependant)</td>
<td>100 bps to 1 kbps</td>
</tr>
<tr>
<td><strong>General</strong></td>
<td></td>
</tr>
<tr>
<td>Mass, kg</td>
<td>1.1</td>
</tr>
<tr>
<td>Power, W</td>
<td>2(+/- 0.2)</td>
</tr>
<tr>
<td>Voltage, V</td>
<td>28.0 (+/- 4.0)</td>
</tr>
</tbody>
</table>
Langmuir probe electronic units
RFA functional block diagram

- Analogue Front End
- Wave Recorder
- EMI Filter
- Power Management
- Digital Vector Receiver
- E-field antennas
- B-field antenna
- TC&TM
- Control Unit
- DC/DC
# RFA main characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
</tr>
<tr>
<td>Mass, kg</td>
<td>1.50 (+10% / - 30 %)</td>
</tr>
<tr>
<td>Power, W</td>
<td>4.5 (+20% / - 30 %)</td>
</tr>
<tr>
<td>Voltage, V</td>
<td>24 – 32</td>
</tr>
<tr>
<td>Dimension, mm</td>
<td>190.0x150.0x90.0</td>
</tr>
<tr>
<td><strong>Functional</strong></td>
<td></td>
</tr>
<tr>
<td>Frequency range</td>
<td>100.0 kHz to 18.0 MHz</td>
</tr>
<tr>
<td>Spectral resolution</td>
<td></td>
</tr>
<tr>
<td>between 0.1-1.0 MHz</td>
<td>10.0 kHz</td>
</tr>
<tr>
<td>between 1.0-18 MHz</td>
<td>100.0 kHz</td>
</tr>
<tr>
<td>Dynamic range, dB@BW</td>
<td>84dB – 96dB</td>
</tr>
<tr>
<td><strong>Operational</strong></td>
<td></td>
</tr>
<tr>
<td>TM stream</td>
<td>~ 2 packets / sec</td>
</tr>
<tr>
<td>TM packet length</td>
<td>120 byte (960 bits)</td>
</tr>
<tr>
<td>Internal memory buffer</td>
<td>256 kB</td>
</tr>
<tr>
<td></td>
<td>(~1 h. of measurement without TM dump)</td>
</tr>
</tbody>
</table>
RFA antennae
Assembling of OBSTANOVKA engineering model
CONCLUSION

• The OBSTANOVKA-1 project united the knowledge and skill of the space scientists and engineers from 7 European countries and the PWC instrumentation developed by this team seems to be the most sophisticated device ever operating onboard ISS for waves and plasma study.

• The realization of this project will allow answering the number of scientific and technological questions, especially one of them being of vital importance: the EMC conditions on the ISS surface and in near-surface zone.

• One of the most important issue of long-term EMC study will be the validation of the achievable sensitivity threshold for the EM instrumentation mounted in NSZ of ISS, what will give definite answer of the ISS applicability for the study of Space Weather, including ionospheric response to the powerful natural hazards at the Earth’s surface.
THANK YOU FOR YOUR ATTENTION!