External Payload Platform

A new Cubesat testbed and payload hosting platform on the International Space Station with reliable fast-track and low-cost mission scenario

Dr. P. C. Steimle*, K. Kuehnel**, K. Woellert***

* Airbus Defence and Space, Bremen, Germany
** Airbus DS Space Systems Inc., Houston, Texas
*** NanoRacks LLC., Washington D. C.

12th Annual CubeSat Developers’ Pre-Conference Workshop
Why being outside ISS?

- Controlled environment
- Commanding of payload from your desk
- Microgravity
- Radiation environment of low Earth orbit
- Vacuum environment
- Thermal environment
- View on Earth
- View to the stars
External Platform on JEM-EF

External Platform

- Up to 9 4U cubesat size payloads outside the ISS
- Standard mission duration 15 weeks
- Excellent viewing conditions for Earth observation
- Full end-to-end mission service
External Platform System Design

Standard payload provisions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>28 Vdc ± 2 V or 120 Vdc as option</td>
</tr>
<tr>
<td>Total power</td>
<td>30 W at 28 Vdc</td>
</tr>
<tr>
<td>Maximum current</td>
<td>2 A</td>
</tr>
<tr>
<td>USB 2.0 bus</td>
<td>5 Vdc / 500 mA, non-switchable</td>
</tr>
<tr>
<td>Total payload data rate</td>
<td>up to 8 Mbit/s</td>
</tr>
</tbody>
</table>

- EP provides all functions of the conventional spacecraft bus
- Ideal platform for small size hosted payloads
- No further subsystems necessary
- Improved anomaly resolution by human in the loop

WiFi interface
Grapple fixture for robotic arm operations
Avionics
Experiment packages baseplate
External Platform – Flight Unit
External Platform Payload Configurations

EPP-P standard 4U size payload package

Unique payload configuration

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
</table>

10 cm  40 cm  60 cm  58 cm  57 cm
External Platform End-to-end Service

- **Launch**: 1 year
- **Transfer outside**: 4+ months
- **Installation**: payload mission
- **Payload Return**
External Platform End-to-end Service

- End-to-end communication with your payload covered by the EP Service
  - Console on your own desk
  - Near-real time data link available

- On-board data management by EP-DMS
  - Data storage in NanoRacks’ EXPRESS rack in JEM-PM
  - Handling of downlink data by ISS data management system

- Complete ground segment provided by ISS
  - Communication front end MSFC
EPP-based In-orbit Testing & Demonstration

<table>
<thead>
<tr>
<th>Technology Demonstration</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRL 1</td>
</tr>
<tr>
<td>TRL 2</td>
</tr>
<tr>
<td>TRL 3</td>
</tr>
<tr>
<td>TRL 4</td>
</tr>
<tr>
<td>TRL 5</td>
</tr>
<tr>
<td>TRL 6</td>
</tr>
<tr>
<td>TRL 7</td>
</tr>
<tr>
<td>TRL 8</td>
</tr>
<tr>
<td>TRL 9</td>
</tr>
</tbody>
</table>

- Accelerated improvement of available technologies, system concepts and abilities
- Reduction of the time to market of space-related products
- Cost-optimization of mission scenarios
- Fast demonstrations of mission scenarios
- Test your satellite components, sensing concept etc. at low risk and low cost
EPP-based Remote Sensing

**ISS attitude-related parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal attitude</td>
<td>Z Nadir (Only 6 hours per year in other z-orientation)</td>
</tr>
<tr>
<td>Operational attitude</td>
<td>Roll, Yaw ±15 deg Pitch +10 to -20 deg</td>
</tr>
<tr>
<td>Attitude accuracy</td>
<td>±3.5 deg per axis</td>
</tr>
<tr>
<td>Attitude estimation</td>
<td>0.5 deg per axis (3 sigma)</td>
</tr>
<tr>
<td>Attitude stability</td>
<td>0.01 deg/s per axis (3 sigma)</td>
</tr>
</tbody>
</table>

Flight direction
Earth visibility
ISS passes over 85% of the surface and 95% of the world’s populated landmass every 1 to 3 days.

ISS orbit-related parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orbital inclination</td>
<td>51.65 deg</td>
</tr>
<tr>
<td>Perigee / apogee altitude</td>
<td>413 km / 417 km</td>
</tr>
<tr>
<td>Orbital period</td>
<td>92.89 minutes</td>
</tr>
<tr>
<td>Beta angle variation</td>
<td>-75 to +75 deg</td>
</tr>
<tr>
<td>Orbit position error</td>
<td>6 m</td>
</tr>
<tr>
<td>Semi-major axis error</td>
<td>20 m</td>
</tr>
<tr>
<td>Revisit frequency</td>
<td>1 – 3 days depending on latitude</td>
</tr>
</tbody>
</table>

ISS Nadir range

Latitude = -51.65°
Japanese Exposed Facility (JEM-EF) in currently manifested payload configuration.

[National Aeronautics and Space Administration, JEM EFU Site 4 NanoRacks FOV View, Manipulator Analysis Graphics and Interactive Kinematics (MAGIK) Team, AI 2610, 2012]
Fisheye Field of View at JEM-EF site 4 towards ISS port side with other payload on JEM-EF Site 8.

[National Aeronautics and Space Administration, JEM EFU Site 4 NanoRacks FOV View, Manipulator Analysis Graphics and Interactive Kinematics (MAGIK) Team, AI 2610, 2012]
External Platform Payload Attitude Stability

Jitter vibrations on JEM-EF

RMS acceleration, g

Frequency, Hz

Rotation [arcsec]

Frequency [Hz]

RMS acceleration, g

Jitter vibrations on JEM-EF

August 2015
Conclusion and outlook

Flight hardware is ready for hand-over from Airbus DS to NanoRacks
EPP manifested for upload with HTV-5 in August 2015
First payload mission preparations have started
Airbus DS will provide a Flight Environment Verification for permanent installation on the EPP, data will be made available
- Acceleration in 3 axes
- Temperature
- Radiation

EPP will be ready for service very soon!

<table>
<thead>
<tr>
<th>Type of mission</th>
<th>External Platform Opportunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote Sensing</td>
<td>▪ Nadir view with 40 deg swath</td>
</tr>
<tr>
<td></td>
<td>▪ Unconstrained view from wake to ram direction</td>
</tr>
<tr>
<td></td>
<td>▪ Maximum contaminant deposition 1x10^{-14} g cm^{-2}s^{-1}</td>
</tr>
<tr>
<td>Use of microgravity</td>
<td>Quality up to 10^{-6} g on JEM-EF with single distortion effects</td>
</tr>
<tr>
<td>Use of vacuum</td>
<td>Vacuum quality approx. 10^{-5} Pa depending on ISS orbit altitude and solar activity</td>
</tr>
<tr>
<td>Meteoroids, space debris monitoring</td>
<td>JEM-EF site no.6 can be made available for ISS ram view</td>
</tr>
<tr>
<td>Antenna testing and RF utilization</td>
<td>▪ Frequency coordination with ISS</td>
</tr>
<tr>
<td></td>
<td>▪ ITU license necessary</td>
</tr>
<tr>
<td>Propulsive element testing</td>
<td>▪ Pressure vessel use not restricted</td>
</tr>
<tr>
<td></td>
<td>▪ No toxic propellants</td>
</tr>
</tbody>
</table>

Type of mission: External Platform Opportunity

Remote Sensing
- Nadir view with 40 deg swath
- Unconstrained view from wake to ram direction
- Maximum contaminant deposition 1x10^{-14} g cm^{-2}s^{-1}

Use of microgravity
- Quality up to 10^{-6} g on JEM-EF with single distortion effects

Use of vacuum
- Vacuum quality approx. 10^{-5} Pa depending on ISS orbit altitude and solar activity

Meteoroids, space debris monitoring
- JEM-EF site no.6 can be made available for ISS ram view

Antenna testing and RF utilization
- Frequency coordination with ISS
- ITU license necessary

Propulsive element testing
- Pressure vessel use not restricted
- No toxic propellants

August 2015
What our launching customers do ...

<table>
<thead>
<tr>
<th>Customer</th>
<th>Payload</th>
<th>Mission scope</th>
</tr>
</thead>
</table>
| Yosemite Space                                             | GumstixTM                                    | ▪ Principal investigator Kathleen Morse, Ph.D.  
▪ Space-based radiation studies to investigate the feasibility of the Gumstix Computer On Module (COM) technology for use in non-critical computationally intensive space applications |
| Florida Institute of Technology                             | Development and Deployment of Charge Injection Device (CID) Sensors for Space-Based Extreme Contrast Ratio Imaging | ▪ Principal investigator Daniel Batcheldor, Ph.D.  
▪ Space-based test of an innovative and novel Charge Injection Device (CID) imager technology in the space environment                                    |
| A-76 Technologies                                           | Characterization of A-76 Corrosion Inhibitors in the Space Environment | ▪ Characterize effectiveness of A-76 corrosion inhibitors and lubricants for metals in the space environment                                                                                                    |
| Honeywell and Morehead State University, Space Sciences Center | TRL7 Validation of Dependable Multiprocessor (DM) Technology | ▪ Principal investigators John Sampson, Ph.D., Benjamin Malphrus, Ph.D.  
▪ Benchmark performance and radiation-induced computational errors of DM Technology while conducting computationally intensive processing in the space environment |
| Arquimea Ingeniería, S.L.U. (Spain)                        | REsettable Hold-Down and Release ACTuator (REACT) | ▪ EU Horizon 2020 funded project with multiple European project partners (Arquimea Ingeniería, S.L.U., EADS CASA Espacio, Surrey Satellite Technology Ltd., AVS, Universidad del Pais Vasco, ESR Technology Ltd., Spacetechn GmbH)  
▪ In-orbit test of SMA-based actuators                                                                                                                   |
Contact

Ron Dunklee
CEO, Airbus DS Space Systems Inc.
Email: rdunklee@airbusdshouston.com

Dr. Per Christian Steimle
ISS Commercial Applications
Airbus Defence and Space, Bremen, Germany
Email: per-christian.steimle@airbus.com

Kirk Woellert
External Payloads, NanoRacks LLC.
Email: jmanber@nanoracks.com

Thank you for your attention!