Adaptation and Optimization of the RIT-μX miniaturized Ion Propulsion System for Small Satellites

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Outline

- The RIT Propulsion System Family
- Background and Heritage
- Selection of Propulsion Systems
- Cost Driving Elements for Geo Satellites and Scientific Missions
- System Comparison: (ESA) Science System vs. Small Satellites System
- RIT-μX Performance
- Finally…
Missions and their Propulsion Systems – Science, GEO, Interplanetary (Non Small Satellites Applications)

- **Orbit Transfer GEO Satellites**
  - Thrust: 300-1000mN
  - Power: 5-20kW

- **In Orbit Service GEO Satellites**
  - Thrust: 10-100mN
  - Power: 0.5-5kW

- **Interplanetary Probes**
  - Thrust: 100-300mN
  - Power: 5-10kW

- **In-Situ Fine positioning and orbital control**
  - Thrust: µN-mN
  - Power: 50-500W

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**LINK to Small Satellites**
## RIT-μX is embedded in the RIT thruster family

<table>
<thead>
<tr>
<th>Thruster</th>
<th>RIT-μX</th>
<th>RIT-10/EVO</th>
<th>RIT-15</th>
<th>RIT-22</th>
<th>RIT-2X</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>nominal thrust</strong></td>
<td>50 – 500 µN</td>
<td>15 mN</td>
<td>50 mN</td>
<td>150 mN</td>
<td>&gt;165 mN</td>
</tr>
<tr>
<td><strong>extended / on request</strong></td>
<td>3 – 3000 µN</td>
<td>5 – 25 mN</td>
<td>1)</td>
<td>10 – 70 mN</td>
<td>50 – 200 mN</td>
</tr>
<tr>
<td><strong>Isp</strong></td>
<td>300 – 3000 s</td>
<td>&gt; 3300 s</td>
<td>&gt; 3300 s</td>
<td>&gt; 3300 s</td>
<td>&gt; 3300 s</td>
</tr>
<tr>
<td><strong>max. demonstrated</strong></td>
<td>&gt; 3500 s</td>
<td>&gt; 3500 s</td>
<td>&gt; 4000 s</td>
<td>&gt; 6000 s</td>
<td></td>
</tr>
<tr>
<td><strong>nom. power</strong></td>
<td>&lt; 50 W</td>
<td>470 W</td>
<td>1500 W</td>
<td>4580 W</td>
<td>&lt; 4.8KW</td>
</tr>
<tr>
<td><strong>mass</strong></td>
<td>440 g</td>
<td>1.8 kg</td>
<td>2.8 kg</td>
<td>7.7 kg</td>
<td>&lt; 8.8kg</td>
</tr>
</tbody>
</table>

### Application

- **NSSK**
- **Primary propulsion**4)
- **Electrical orbit raising**5)
- **Ultra fine thrust control**

1) RIT 10 EVO
2) Optimised for Geo
3) Optimised for Science
4) For Science missions
5) For Geo missions
6) nominal Operation
7) Full Range
RIT-μX – Motivation and Application

- Compensation of atmospheric drag
- Compensation of space weather
- Formation Flying & Distributed Instruments
- Actuator for Telecommunication Satellites

Requirements
(Subset of key requirements)
- High Thrust Resolution
- Fast Thrust Response
- Low Thrust Noise
- Micro to Millinewton Thrust Regime
- Non toxic, inert propellant
- Direct electric feedback of produced thrust
- Free of (magnetic) torque
Industrial Approach – One Thruster body for different thrust ranges and applications

- Airbus’s industrial approach bases on one thruster body for all relevant thrust ranges
- Needs of science missions are very specific
- 150-2500µN Thrust range has the broadest field of applications
- Successful & early in orbit operation and attractive recurring price are key to capture commercial market
Principle and Heritage

In a first step Xenon is ionized in the electro-magnetic field of an rf-coil. Xenon ions are accelerated in the electrostatic field of a grid system (ion optics system). Free of permanent magnets, inherent thrust stability, highly scalable. Space proven technology:

- Ionisation
- Acceleration

EURECA
ARTEMIS
Standard selection criterion for propulsion technology

First Order:

Refined Assessment:

Specific impulse

Heavy S/C

Low mass S/C

System specific Impulse
Could a new sight to propulsion create a paradigme change?

- Propulsion considered expensive and risky
- Mission designed to spacecraft prime or operator need
- Higher Orbits
  - Minimized delta-v
- No propulsion
- Simple and low ISP Systems
- Propulsion considered as enabler
- Mission designed to USER needs
- Lower Orbits
  - Increased delta v
  - Relaxed environment for EP electronics
  - Improved observation performance
  - Inherent Answer to debris avoidance
Cost Drivers in RIT for GEO and RIT µX Science Systems

Radiation
15+ years in Geo
6+ years at Lagrangian Point

Liability

RITµX:
Quality of thrust: µN Resolution, Stability, Response, Low Noise

RIT-µX:
System Complexity
Coordinated Simultaneous Operation of 8 and more Thrusters

Mission Specific Qualification

Drivers are introduced by mission and NOT technology
Comparing two System Approaches

PPU Centered Topology

Distributed Topology
Present work is focused on science

However:
With the development of an RIT-µX bases neutralizer the work on a Distributed System is started
RIT-µX System Thrust Modulation Capabilities

Graph showing thrust modulation over time.
Results from AIRBUS DS LET Micro Newton Test Facility (Friedrichshafen, Lake Constance)

LET – Laboratory for Enabling Technologies

Micro Newton Thrust Balance

RIT-μX500 performing 1μN Thrust Steps (Direct thrust measurement):
Results from AIRBUS DS LET Micro Newton Test Facility (Friedrichshafen, Lake Constance)

RIT-μX₅₀₀ performing 0.1 μN Thrust Steps (Direct thrust measurement):

2016.04.16; 0.1 μN Steps at 56 μN Thrust Level
RIT Work – Team Work

- University of Gießen
  Davar Feili, Stefan Weis and Benjamin Lotz
  Kristof Holste and Peter Köhler

- All the colleagues and friends inside Airbus DS
  Franz Georg Hey (Friedrichshafen Micro Balance)

- All the helpful and highly motivated people and firms not listed here

- The German Space Agency DLR

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- Your Feedback is much appreciated (hans.leiter@airbus.com)

Thank you for your attention!