MEPS: A Low Power Electric Propulsion System for Small Satellites

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MEPS (Micro-Satellite Electric Propulsion System) is programme aiming at the qualification of a propulsion subsystem based on a low power Hall Effect Thruster (~150-300W).

The system has been conceived for being used onboard of a small satellite platform, typically with a total mass at launch of less than 250 kilograms. Possible applications:

- Orbit maintenance of spacecraft in Low and Very-Low Earth Orbit (LEO and V-LEO)
- Accurate final orbit insertion after separation from launcher
- Spacecraft end-of-life disposal

MEPS is jointly financed by the European Space Agency (ESA) and the Israeli Space Agency (ISA)
Note: part of the testing activities will be performed at ESTEC (EP Laboratory)
Main System Components (baseline configuration):

- two Thruster Units
- Power Processing Unit (PPU)
- Propellant Management Assembly (PMA)
- Xe Tank

**MEPS Thruster - Target Performance**

- Max. Input Power: 300 W
- Anodic Power: 100 - 250 W
- Thrust Range: 5 - 15 mN
- Specific Impulse: 800 - 1400 sec
- Lifetime: > 3000 h
MEPS Flexibility: Redundant vs. Single Branch Config.

**PPU**: Power Processing Unit  
**PCM**: Power Control Module  
**PPM**: PPU Power Module  
**TU**: Thruster Unit  
**FU**: Filter Unit  
**XFC**: Xenon Flow Controller  
**PMA**: Prop. Manag. Assembly  
**TSU**: Thruster Switching Unit

<table>
<thead>
<tr>
<th>Configuration</th>
<th>System Mass</th>
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<tbody>
<tr>
<td>Fully Redundant</td>
<td>&lt; 15 kg</td>
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<tr>
<td>Single Branch</td>
<td>&lt; 9 kg</td>
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Low Power Hall Effect Thruster

**CAM 200 (Rafael)**
- Non conventional magnetic field topology, to extend thruster lifetime
- Improved ionization efficiency
- More than 700 hrs of cumulated firing time

**HT 100 (Sitael)**
- Permanent Magnets, to reduce thruster size and thermal loads
- Max. Efficiency: 35%
- Thruster weight: 436g
In ascending order of importance:

1) Thruster full characterization / thermal-vacuum thrust operation in our large **LN2-shrouded vacuum facility**

2) Structural Analysis ---> Shock & Vibration Tests

3) **Endurance Test** (presently ongoing: cumulated firing time 480h @ 10.5mN, total impulse >18 kNs)
PPU BB Development

- Thruster Impedance test (Dec 2014) on HT100 and CAM200
- PPU BB Manufacturing (Jan/Feb 2015 Anode Power Supply, Mar/Apr 2015 Cathode Power Supply)
- PPU BB Test, Anode Power Supply (Mar 2015)

![Efficiency Graph]

- Efficiency [%]
- Pout [W]
- Vin = 22V - Vout = 350V
- Vin = 28V - Vout = 350V
- Vin = 34V - Vout = 350V

TURN COUNTERCLOCKWISE TO RISE THE OUTPUT VOLTAGE
MEPS: A Low Power Electric Propulsion System for Small Satellites

MEPS Roadmap: Phase 2A, System EM

- TU EQM Development
- PPU BB Dev’t
- PPU EM Development
- PMA EM Development
- TU EQM Test (Env. / End.)
- EM System Coupling Tests
- Thruster Selection

April 2015

MEPS Roadmap: Phase 2B, System QM

- TU QM Design
- PPU QM Design
- PMA QM Design
- Tank Design
- TU QM MAIT + S&V Test
- PPU MAIT + S&V Test
- PMA MAIT + S&V Test
- Tank MAIT + S&V Test
- QM System Qualification Tests:
  - Functional
  - EMC/ESD
  - TVAC
  - Endurance

CDR / MRR

Final Review (2Q 2018)

Close Out

δPDR (2Q 2016)
Target Applications

- **Drag compensation**: orbit maintenance of spacecraft in Low and Very-Low Earth Orbit (LEO and VLEO) for observation satellites, i.e. Litesat operated by Rafael/ISA

- **LEO large satellite constellations**: with MEPS in single-branch configuration (trade-off between size and reliability)

- **Deorbiting / End of life disposal**

- **Space debris removal** (ion beam shepherd concept, ref. Merino, Ahedo, Bombardelli, “Ion Beam Shepherd Satellite for Space Debris Removal”)
Conclusions

Low power electric propulsion can be a winning option for many missions, sometimes even the only suitable option. Moving quickly towards the qualification and flight demonstration of such a system is thus a high priority.

The aim of MEPS programme is to have a compact, flexible and cheap EP system fully qualified in a three year timeframe.

- **Compact:** the system has to be *lightweight* in order to be appealing for mini- and micro-satellites that can thus take advantage of it, enabling new mission scenarios.

- **Flexible:** both in terms of performance and architecture, MEPS has to fulfill market requirements and demands, *serving a wide variety of missions*.

- **Cheap:** the adoption of a design-to-cost philosophy will allow us to *reduce the selling price*. Controlling system cost is crucial, especially for small satellite market. Large constellations of satellites may open totally new perspectives, trigerring a ‘mass production’ process that would lead to a dramatic reduction of the item selling price.

**MEPS will be the lowest power HET-based propulsion system ever qualified in Europe.**