SITEL LOW POWER ELECTRIC PROPULSION SYSTEMS FOR SMALL SATELLITES

Tommaso Misuri
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SITAEL, Facts & Figures

- **Propulsion division**
- **Headquarters**
- **SMALL SATELLITES**
  - 351 highly qualified employees
- **ADVANCED PROPULSION**
  - 34.1 average age
- **SPACE AVIONICS**
  - State-of-the-art facilities
  - Part of an extended group of hi-tech companies

State-of-the-art facilities

Part of an extended group of hi-tech companies
Smart, modular, scalable, all-electric platform solutions

Wide range of possible missions and applications

From 50kg to 300kg
Low Power Electric Propulsion Technologies

- SITAEL offers full electric propulsion systems for each of its platforms and extends its offer also to smaller satellites (< 50kg)

- Limiting our attention to the thrusters operating at low power levels (<500 W), three different technologies are currently under development at SITAEL:
  
  ✓ **HALL EFFECT PROPULSION**: easily scalable, can operate efficiently over a wide power range

  ✓ **ELECTROTHERMAL PROPULSION**: developed to serve as auxiliary propulsion system on large platforms

  ✓ **FIELD EMISSION PROPULSION**: very high specific impulse, suitable for micro- and nano-satellites
Hall Effect Propulsion @ SITAEL

- HT100
  - Smallsat constellations
  - Orbit insertion / transfer
  - Drag-Compensation
  - Collision avoidance
  - End-of-life disposal

- HT400
  - Orbit raising (LEO-GEO)
  - Space Tug
  - Electric Upper Stage
  - End of life disposal

- HT5k
  - Orbit Raising for large geostationary platforms
  - Space Exploration

- HT20k
HT100 - HT400: Revolutionizing the Small Satellite Market

**NEXT STEPS:**

- **100W Hall Effect Thruster**
  - In-Orbit Demonstration (µHETSat)
  - Test with Iodine as propellant (2018 Q4)
  - Preparing for mid- to high-production rates
  - Qualification of Magnetically Shielded HT100

- **400W Hall Effect Thruster**
  - PPU EM Development
  - Characterization at boundary power levels (300 and 800 W)
  - Extended endurance test

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- ✓ 3500+ hours of cumulated firing time
- ✓ Tested over a wide operating power range (80-250W)
- ✓ TVAC + Structural Tests

- ✓ 600 hours of cumulated firing time
- ✓ Coupled with power processing unit board
- ✓ Revamped Design, Magnetic Shielding
HT100 Propulsion System for μHETSat Mission (Single Thruster)

Propellant Management Assembly

- Power Processing Unit board
- PPU / PCU Tray
- Xe Tank
- 2.8l tank filled with supercritical Xe on the shaker @ SITAEL Bari
- HT100 thruster unit under characterization @ SITAEL Pisa

Payload Bay (satellite bottom block)

- PMA Baseplate
- TU (protruding from the bottom-plate)

Key components:
- LPT: Low Pressure Transducer
- HPT: High Pressure Transducer
- PRA: Pressure Regul. Assembly
- FDV: Fill & Drain Valve
- VCO: Valve Collector
- FRA: Flow Regul. Assembly
‘Mistake’ was focusing too much on the thruster anode: cathode was a less consolidated sub-subsystem at the beginning of development. An important effort was spent on:

✓ Materials and heater design
✓ On-off cycles test
✓ Ignition sequence optimization

<table>
<thead>
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<th>HC1 Main Features</th>
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<tbody>
<tr>
<td>Cathode mass</td>
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<tr>
<td>Heater power</td>
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<tr>
<td>Mass Flow Rate</td>
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<tr>
<td>Max. operating current</td>
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<tr>
<td>Expected lifetime</td>
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SITAE XR-150 Resistojet can work at power levels up to 150 W and can be operated with any non-oxidizing propellant.

XR-150 has been tested both with Xe and Kr and has been conceived as an auxiliary propulsion system, i.e. for large platforms already using Xe-fed propulsion systems.

<table>
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<th>Feeding Pressure</th>
<th>Thrust [mN]</th>
<th>Cold operation Mass Flow Rate (Xe) [mg/s]</th>
<th>Specific Impulse [s]</th>
<th>Hot operation @ 50W Mass Flow Rate (Xe) [mg/s]</th>
<th>Specific Impulse [s]</th>
<th>Hot operation @ 100W Mass Flow Rate (Xe) [mg/s]</th>
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Experimentally validated | Calculated by numerical model
COMFIT
CUBESAT ONE–MODULE FEEP ION THRUSTER

• Thrust: up to 250 μN
• Specific Impulse: 3500 - 5000 s
• Max Power Consumption: < 20 W
• Volume: 0.9 U
• Thruster Dry Mass: 700 g
Field Emission Propulsion: COMFIT

- Based on SITAEL’s long heritage in the Field Emission Propulsion
- Non-hazardous propellant
- Effectively serves mini- and micro-satellites
- Designed with special attention to cost reduction and to the possibility of a large-scale production (key components made by additive manufacturing)
Conclusions

Importance of Low Power Electric Propulsion as:

- Necessary technology to enable new missions by providing a high delta-V capability even to very small platforms
- Mandatory element for all small satellites operating in LEO at least to carry out collision avoidance maneuvers and end-of-life disposal
- Main propulsion system for smallsats operating in large constellations

**SITAEL Target: to have an adequate electric propulsion system for every small platform below 500 kg**

Future steps:
- ✔ In-Orbit Validation of HT100 Propulsion System
- ✔ On ground qualification of HT400 Propulsion System
- ✔ Extended test campaigns of Magnetically Shielded Low Power Hall Effect Thrusters (with permanent magnets)
- ✔ Full experimental characterization of the newly designed Field Emission Thruster,
- ✔ Further Expansion of SITAEL EP Labs for a scaled-up production of propulsion systems (already ongoing)