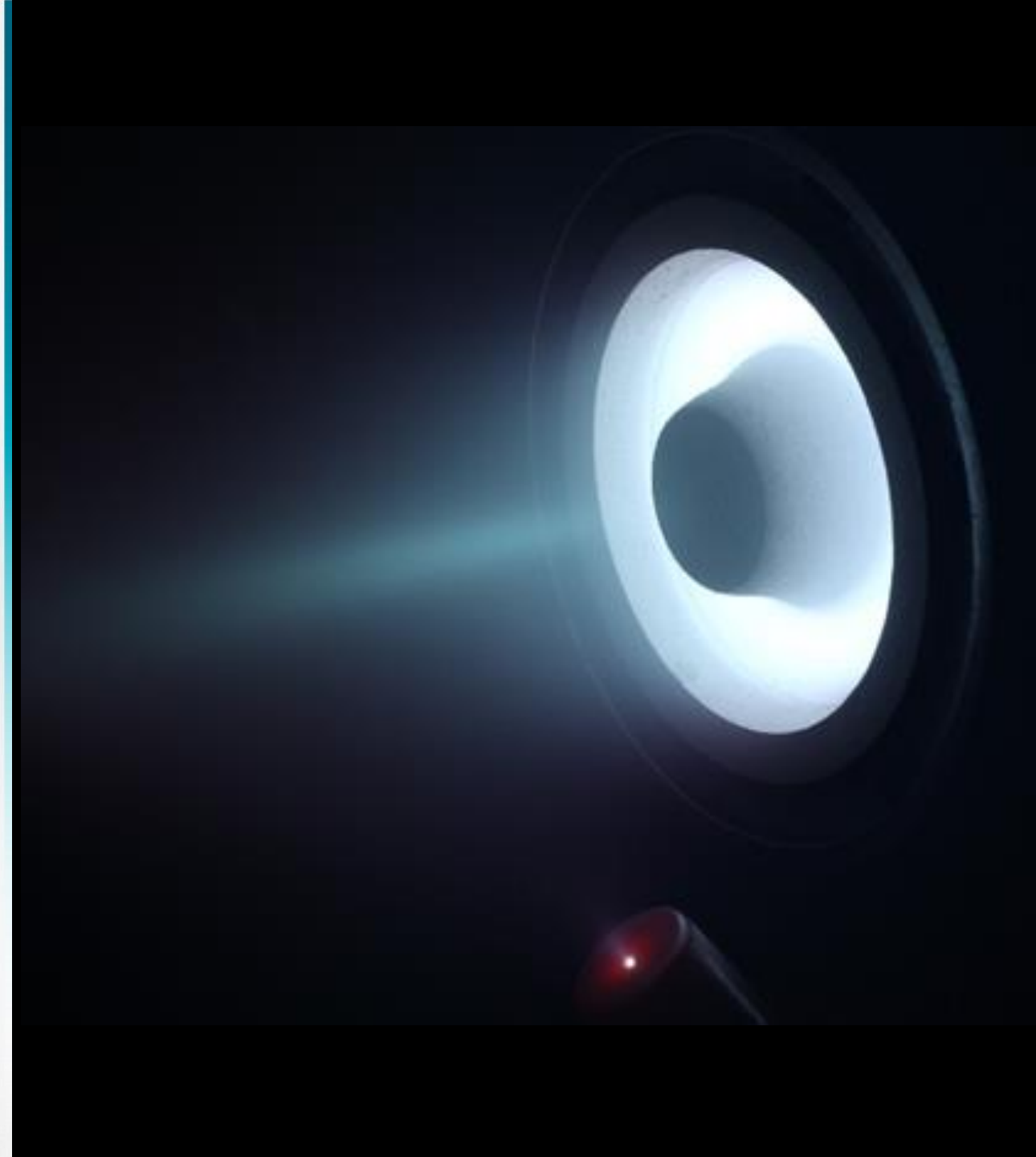
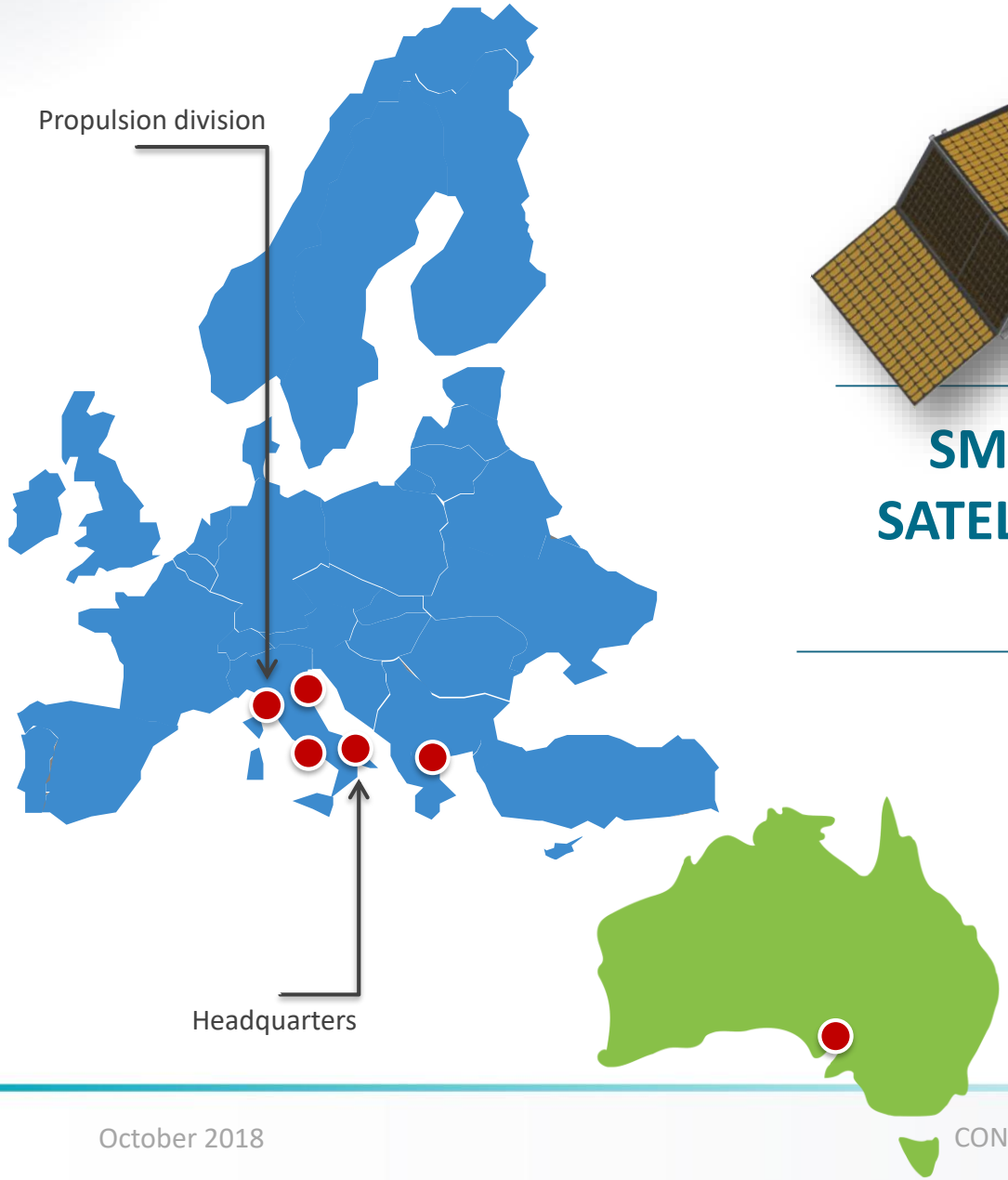
SITAEL LOW POWER ELECTRIC PROPULSION SYSTEMS FOR SMALL SATELLITES

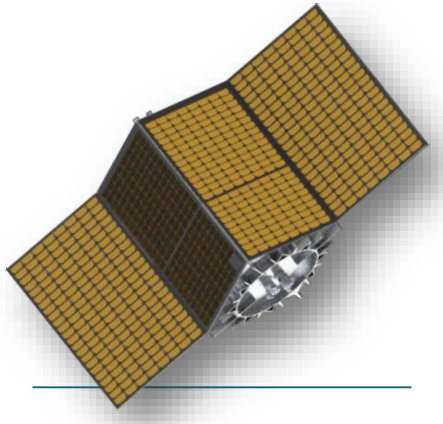
Tommaso Misuri

EPIC Workshop – London, UK
October 2018

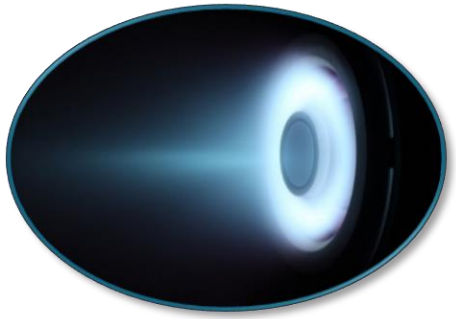


SITAEL, Facts & Figures





SMALL SATELLITES



ADVANCED PROPULSION

SPACE AVIONICS

351 highly qualified employees

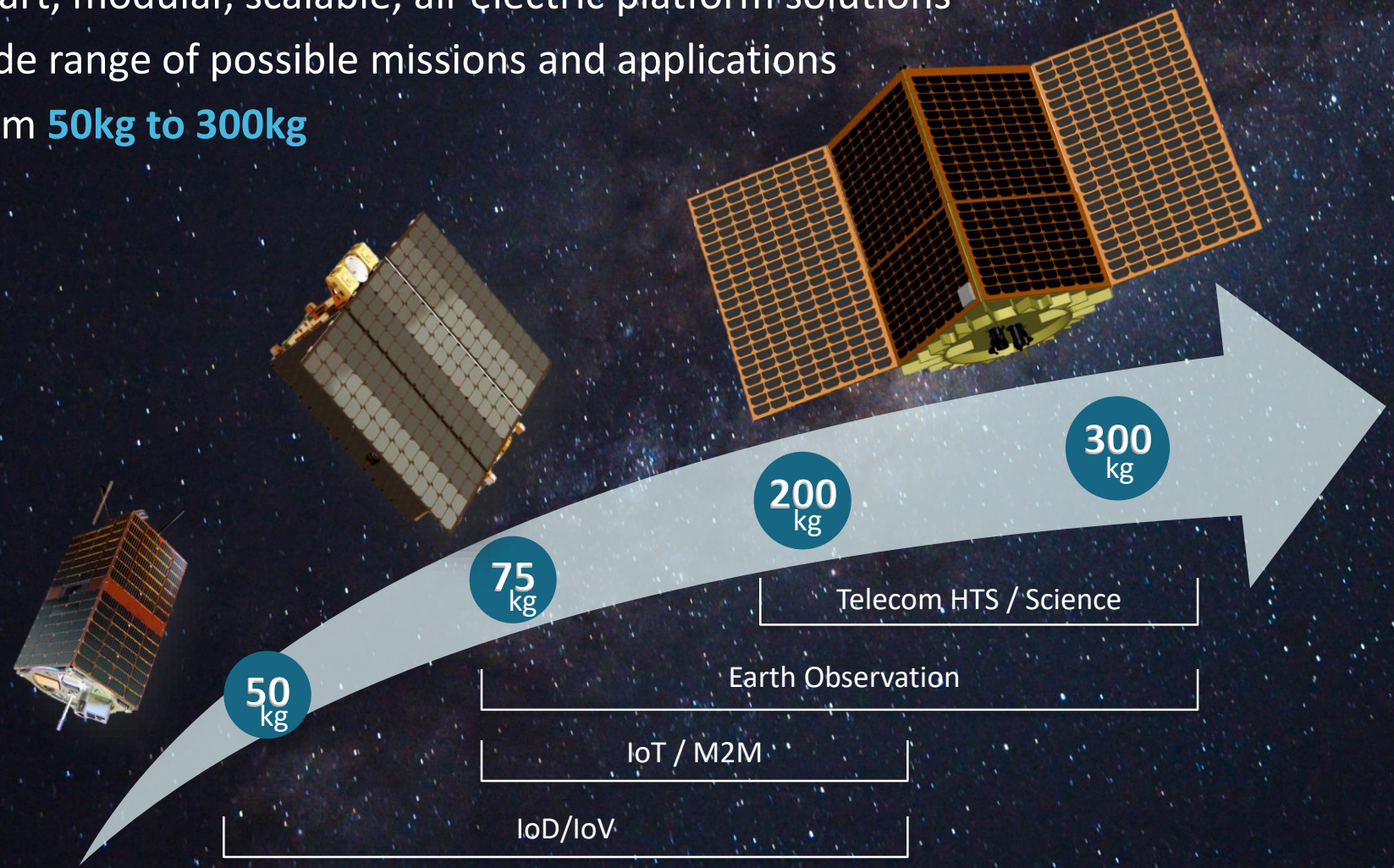
34,1 average age

State-of-the-art facilities

Part of an extended group of hi-tech companies

SITAEL Small Satellites Portfolio

- ✓ Smart, modular, scalable, all-electric platform solutions
- ✓ Wide range of possible missions and applications
- ✓ From **50kg to 300kg**



μHET SAT

STRIVING
IN ORBIT VALIDATION

PLATiNO

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

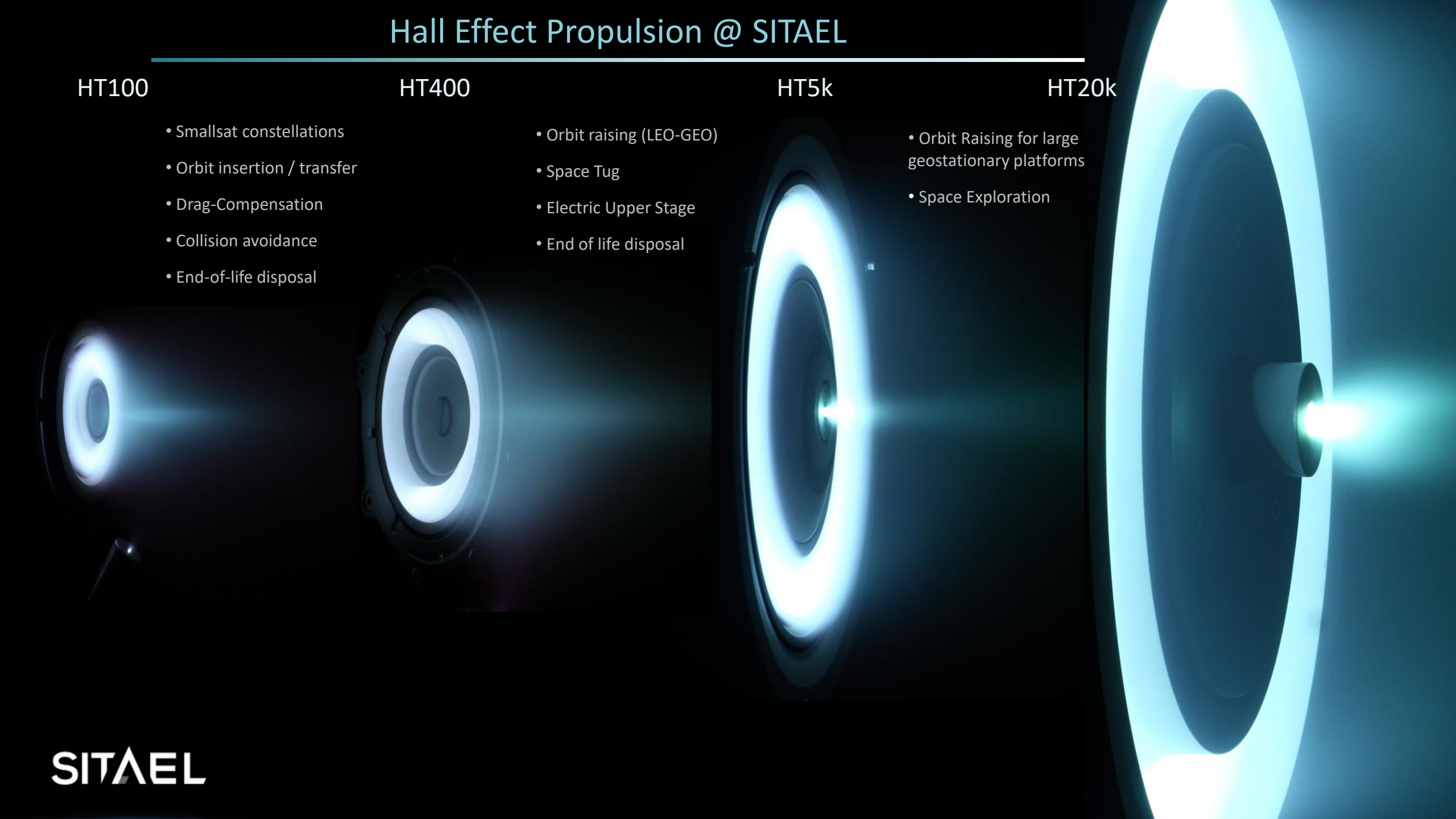
HT400

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

HT5k

- Orbit Raising for large geostationary platforms
- Space Exploration

HT20k



SITAEL

HT100 - HT400: Revolutionizing the Small Satellite Market

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

NEXT STEPS:

In-Orbit Demonstration (μHETSat)

Test with Iodine as propellant (2018 Q4)

Preparing for mid- to high-production rates

Qualification of Magnetically Shielded HT100

100W Hall Effect Thruster

- ✓ 600 hours of cumulated firing time
- ✓ Coupled with power processing unit board
- ✓ Revamped Design, Magnetic Shielding

NEXT STEPS:

PPU EM Development

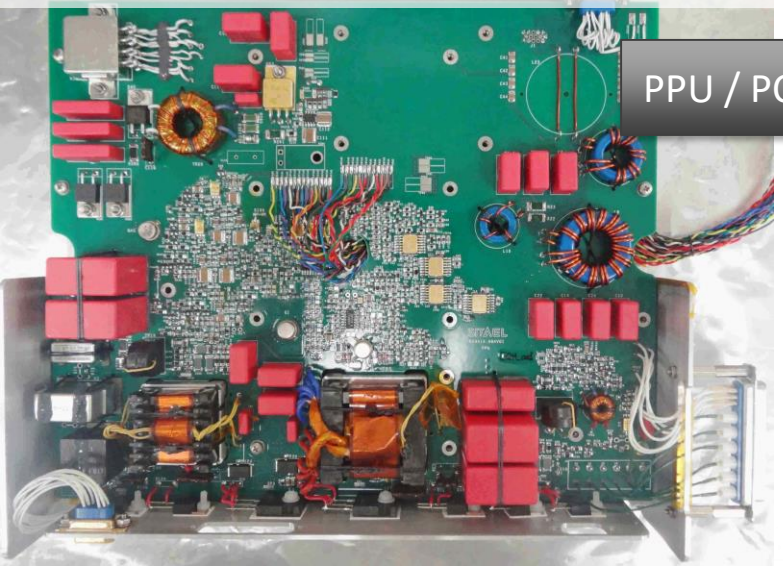
Characterization at boundary power levels (300 and 800 W)

Extended endurance test

400W Hall Effect Thruster

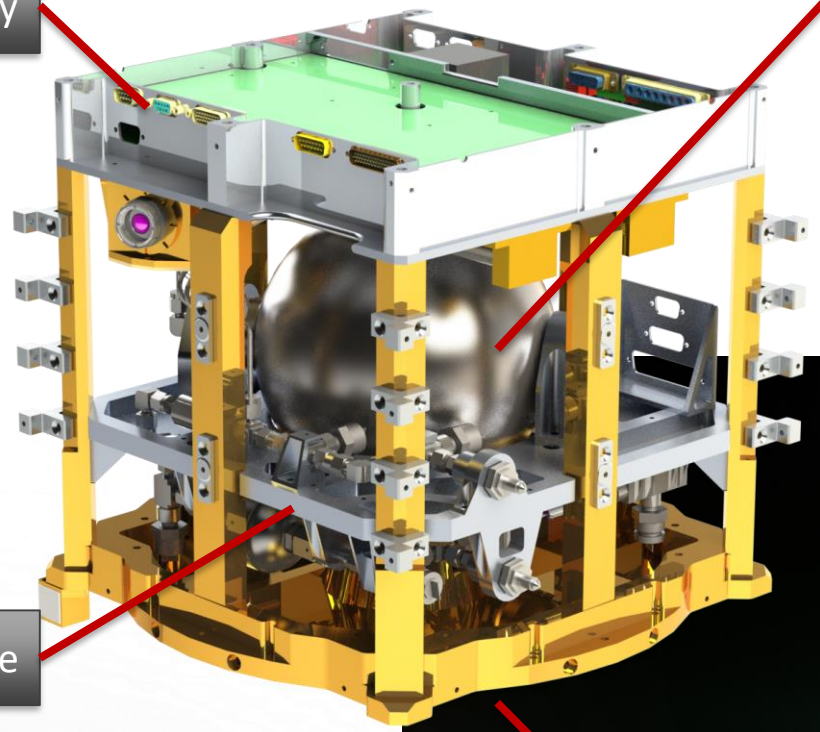
HT100 Propulsion System for µHETSat Mission (Single Thruster)

Power Processing Unit board



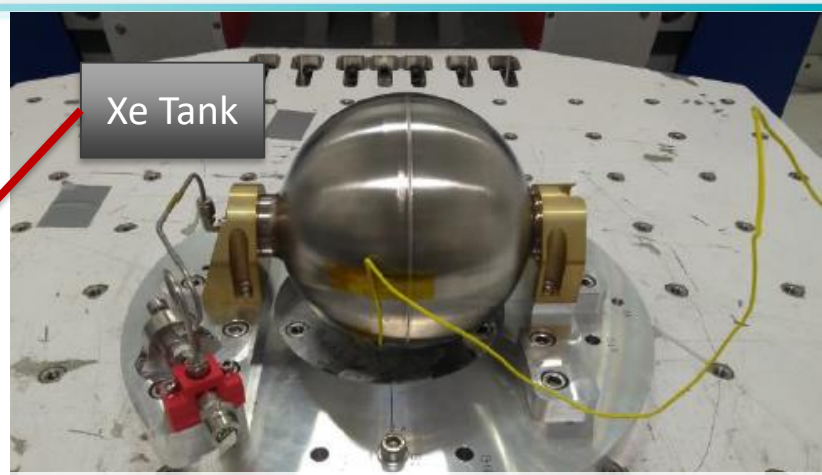
PPU / PCU Tray

Payload Bay
(satellite bottom block)



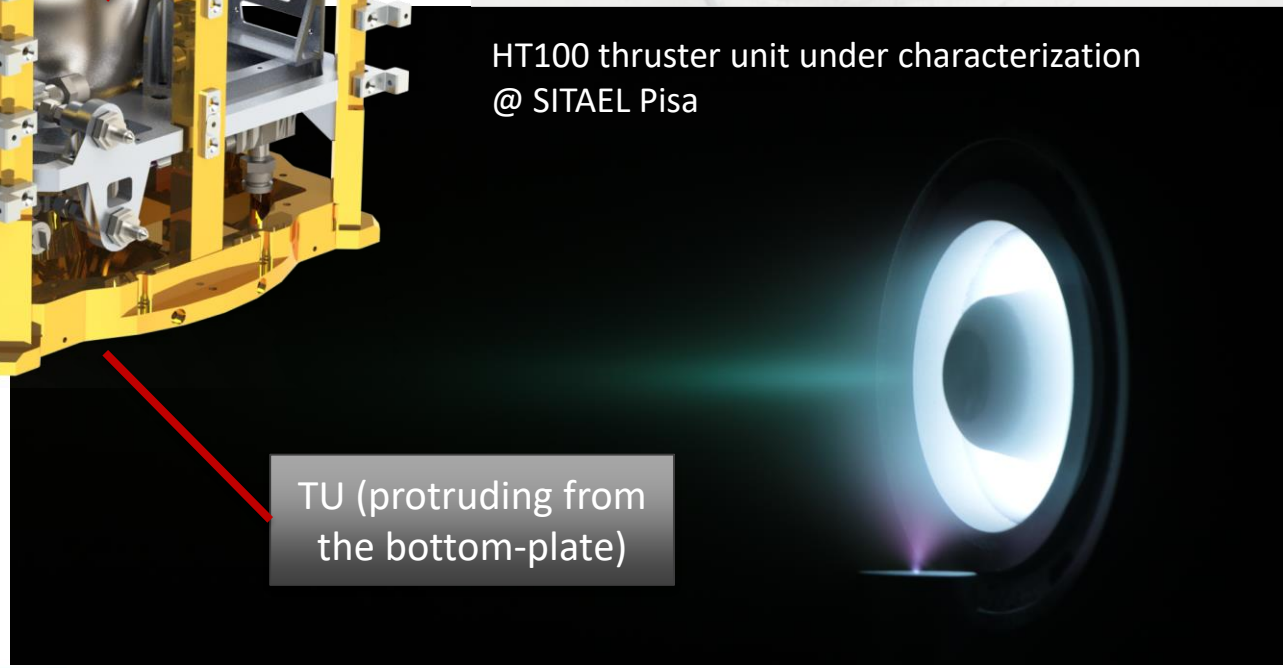
PMA Baseplate

Xe Tank



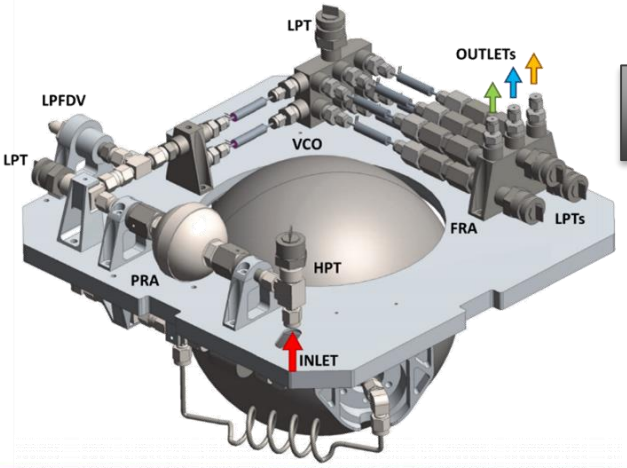
2.8l tank filled with supercritical Xe on the shaker @ SITAEL Bari

HT100 thruster unit under characterization @ SITAEL Pisa



TU (protruding from the bottom-plate)

Propellant Management Assembly



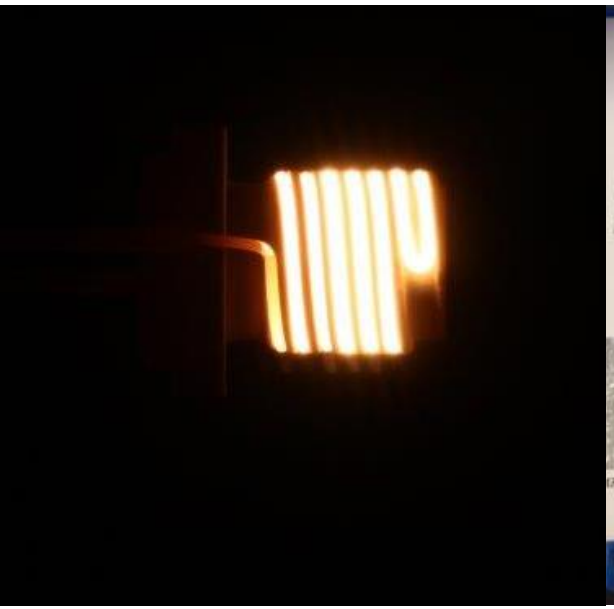
LPT: Low Pressure Transducer
HPT: High Pressure Transducer
PRA: Pressure Regul. Assembly
FDV: Fill & Drain Valve
VCO: Valve Collector
FRA: Flow Regul. Assembly

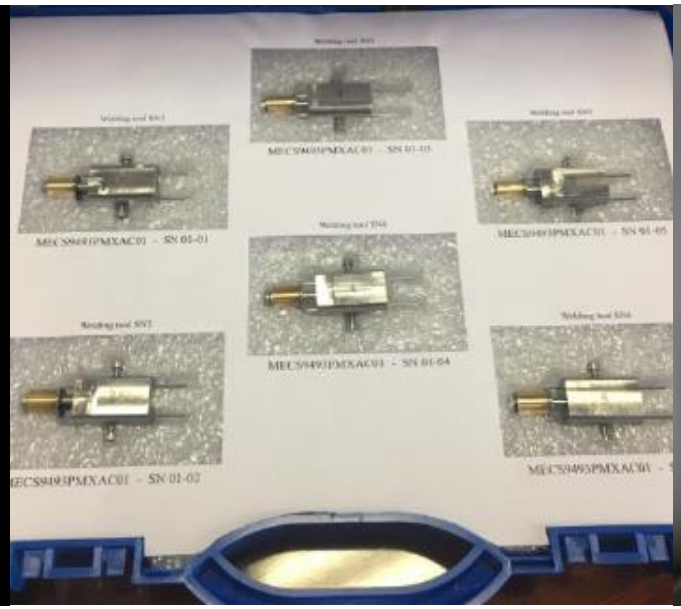
HC1 Cathode Development

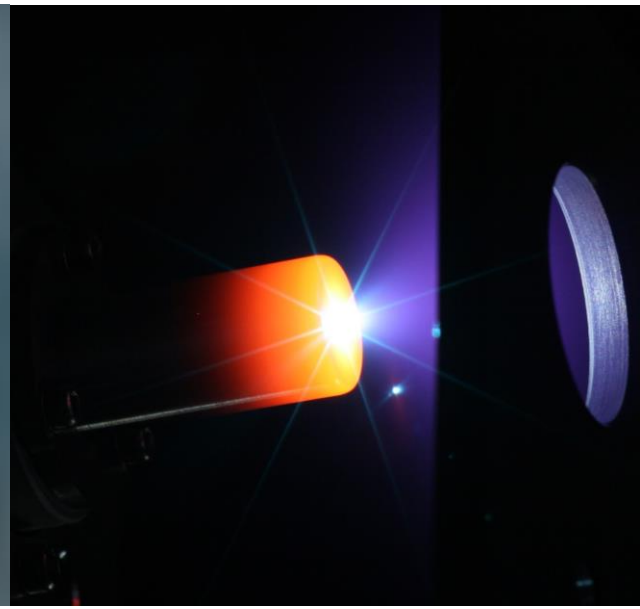
‘Mistake’ was focusing too much on the thruster anode: cathode was a less consolidated sub-subsystem at the beginning of development. An important effort was spent on:

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

HC1 Main Features	
Cathode mass	35 g
Heater power	< 30 W
Mass Flow Rate	0.1 mg/s
Max. operating current	1 A
Expected lifetime	> 4000 cycles > 4000 hours



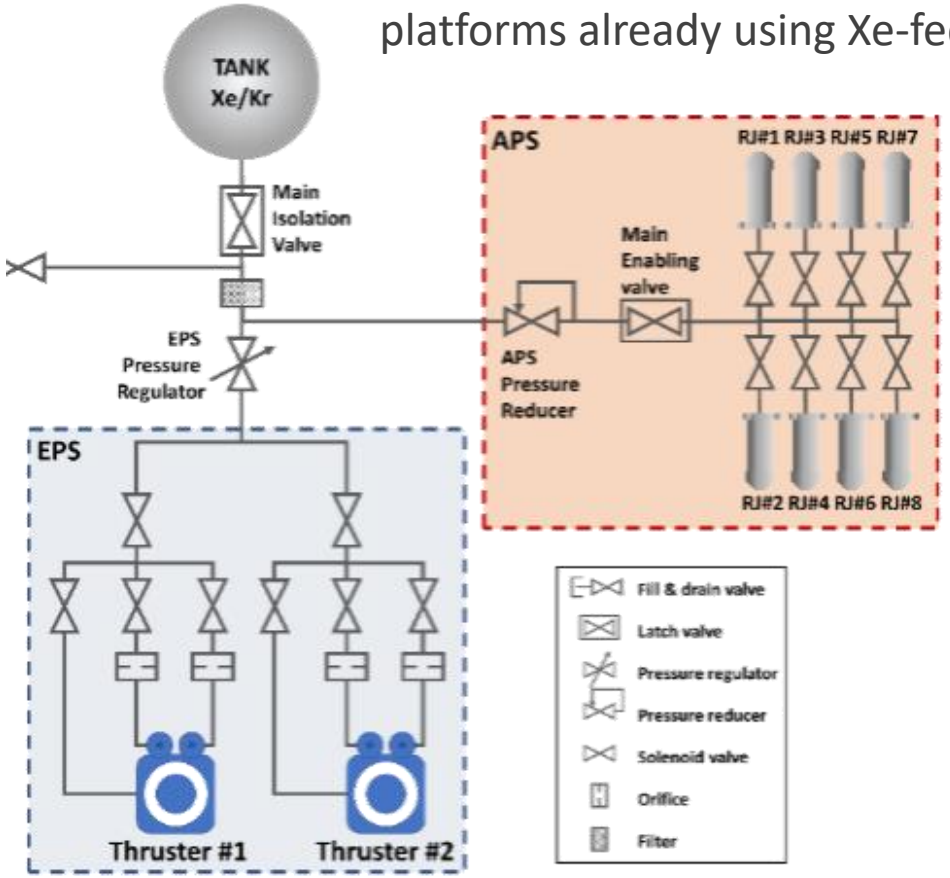




Low Power Electrothermal Propulsion @ SITAEL

SITAEL 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



Feeding Pressure	Thrust	Cold operation		Hot operation @ 50W		Hot operation @ 100W	
		Mass Flow Rate (Xe)	Specific Impulse	Mass Flow Rate (Xe)	Specific Impulse	Mass Flow Rate (Xe)	Specific Impulse
[bar]	[mN]	[mg/s]	[s]	[mg/s]	[s]	[mg/s]	[s]
1.5	39	131	30.4	80	49.7	70	56.8
2	52	175	30.5	107	49.6	94	56.4
2.5	65	215	30.4	133	49.8	121	56.5
2.55	70	235	30.4	143	49.9	-	-
3	80	269	30.4	164	49.7	146	56.6
3.5	96	322	30.4	210	46.6	173	56.6
4	111	373	30.3	257	44.0	200	56.6
4.5	126	423	30.4	304	42.3	227	56.6
5	141	473	30.4	352	40.8	254	56.6
5.5	156	524	30.4	401	39.7	281	56.6

Experimentally validated | Calculated by numerical model

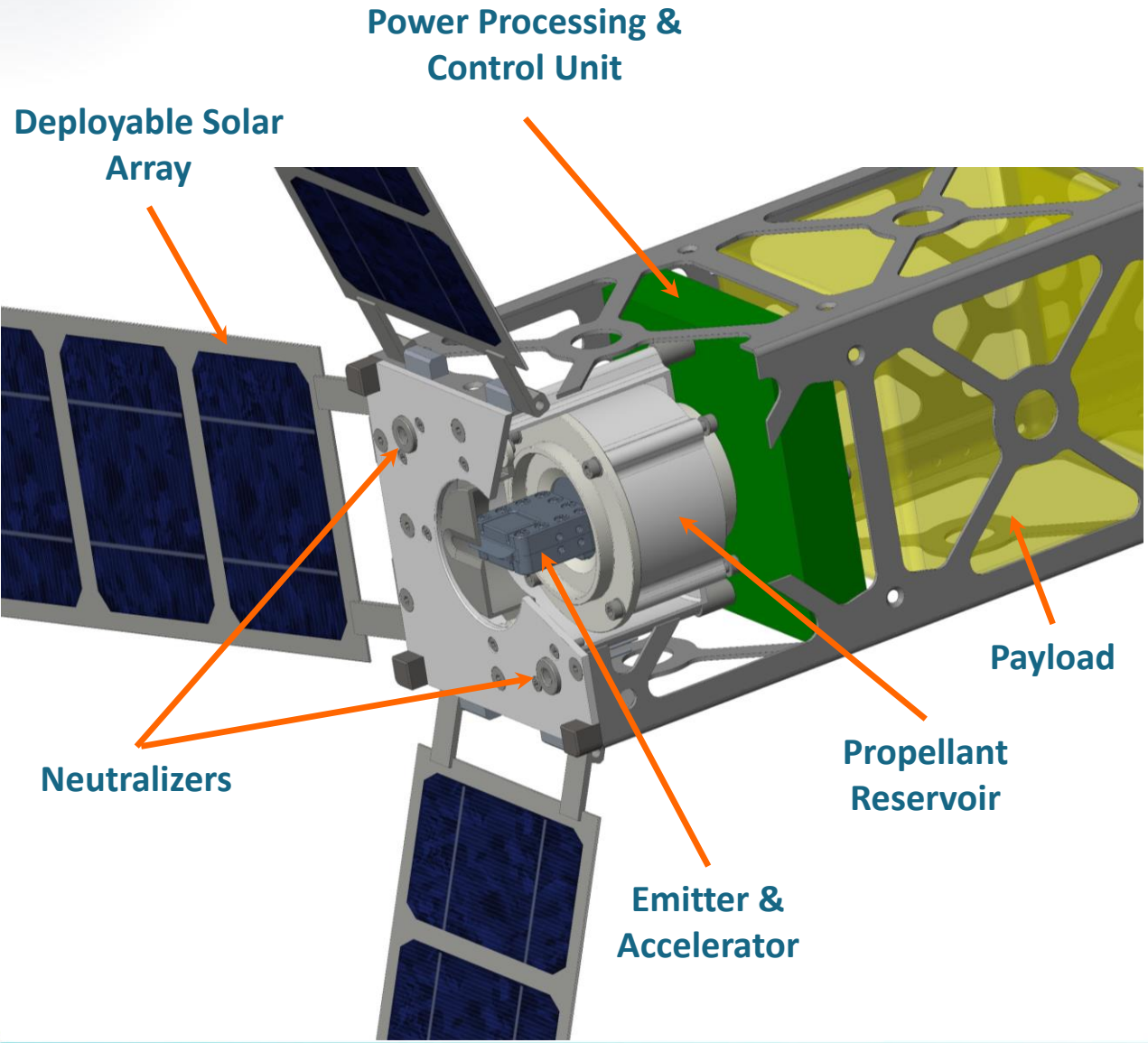
Field Emission Propulsion @ SITAEL: COMFIT

COMFIT

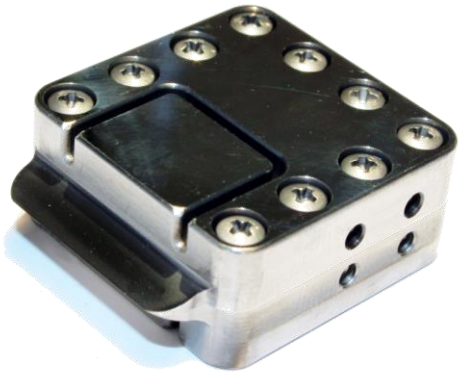
CUBESAT ONE–MODULE FEEP ION THRUSTER

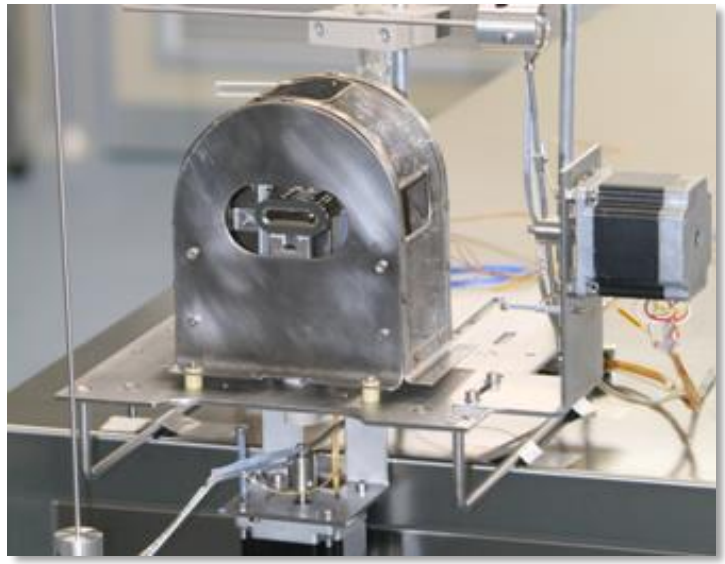
- Thrust: up to 250 µN
- Specific Impulse: 3500 - 5000 s
- Max Power Consumption: < 20 W
- Volume: 0.9 U
- Thruster Dry Mass: 700 g

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)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