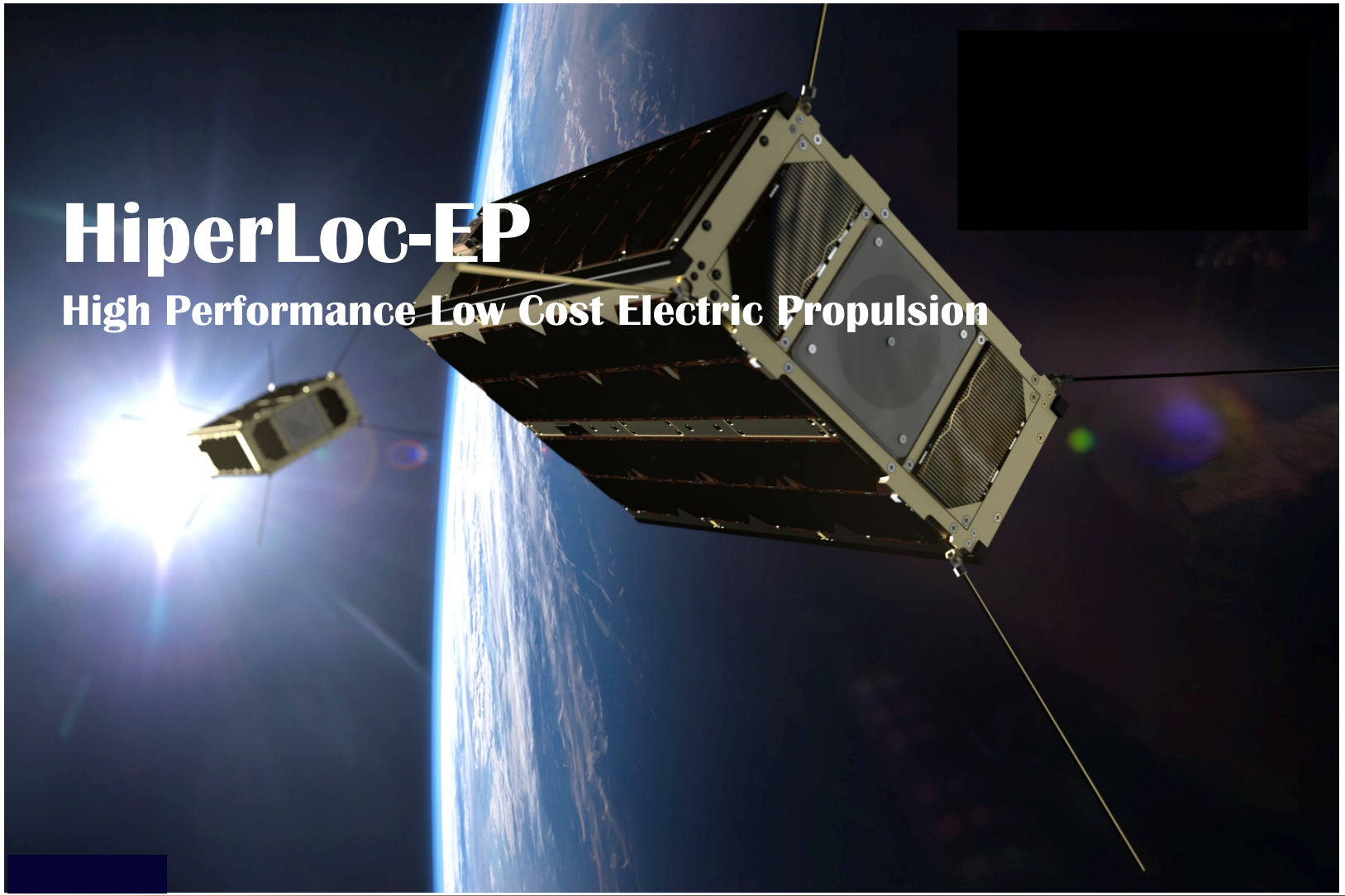


HiperLoc-EP

High Performance Low Cost Electric Propulsion

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

HIPERLOC-EP:
DEVELOPMENT OF ELECTROSPRAY COLLOID ELECTRIC PROPULSION AS A LOW COST DISRUPTIVE PROPULSION TECHNOLOGY

PRESENTER: JOHN STARK QUEEN MARY UNIVERSITY OF LONDON

EPIC Workshop 16th October 2018
London

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

THE TEAM

Project Lead

- Queen Mary University Of London (UK)

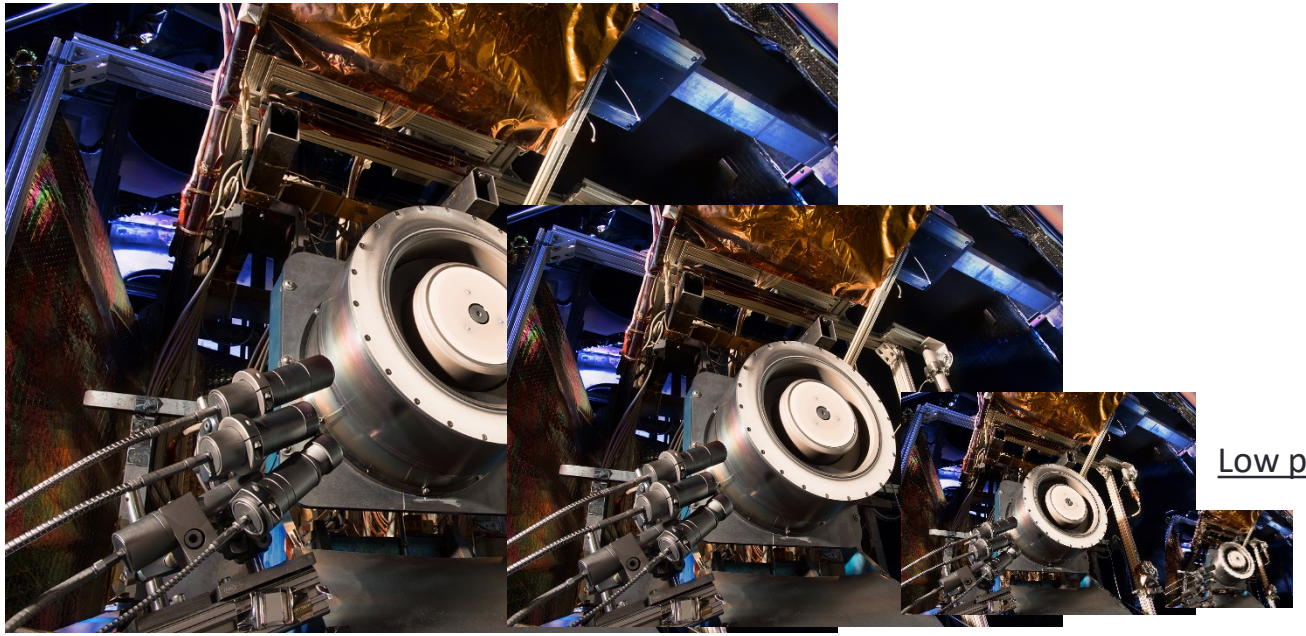
Team Members

- Airbus Defence & Space Ltd (UK)
- NanoSpace AB (Sweden) {Now part of Gomspace}
- SystematIC design BV (Netherlands)

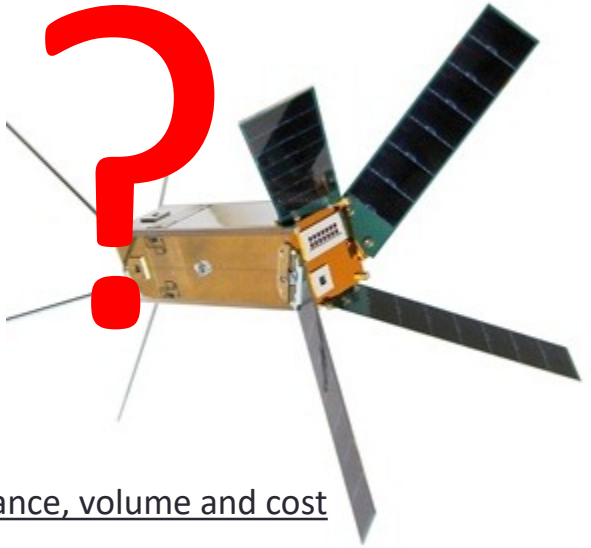
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

Problem

High performance, volume and cost



https://www.quora.com/Whats-NASA-up-to-with-electric-propulsion



Low performance, volume and cost

The HiperLoc team believes that the value of CubeSat missions will significantly improve when a cost effective EP system is available.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

Project Title

*Hi*gh *per*formance L*o*w *c*ost *E*lectric *P*ropulsion system:
HiperLoc-EP

Vision

To develop an Electric Propulsion System having an efficiency and performance comparable to those used on current commercial platforms but fully scalable in thrust from µN to mN with cost an order of magnitude below current systems, thus facilitating the market opportunities for large scale microsatellite constellations and commercial microsatellite platforms

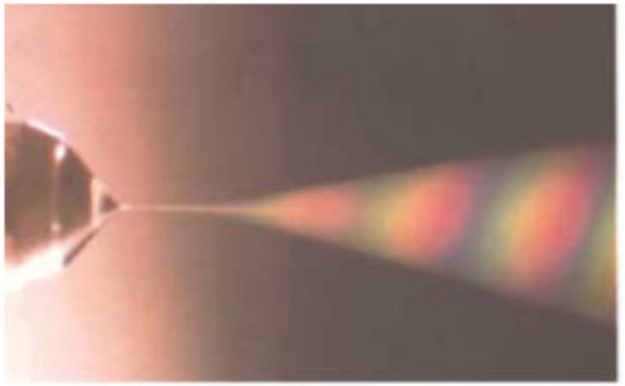
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

The Technology

Electrospray Colloid Electric Propulsion

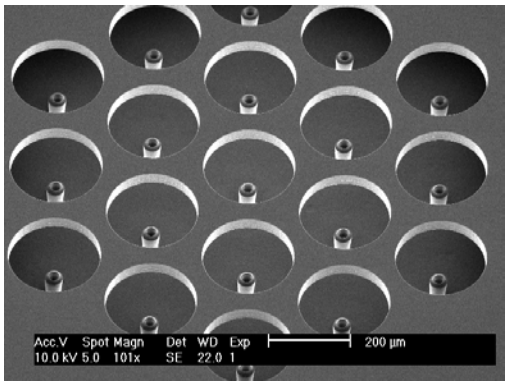
PROCESS

- Conductive liquid flows through an emitter (eg capillary)
- Intense electric field creates a “Taylor cone”.
- Liquid forms a jet which breaks into spray of charged species: ions/clusters or droplets.
- Species accelerate in electric field to high velocity charged plume.
- *Positive* and *Negative* species can be produced (no neutralizer required).



A previous thrust head design

Microthrust (FP7) 2011 to 2014



This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730075

Performance Requirements

(for disruptive capability)

Parameter	Performance Requirements
Total Impulse	> 2000 Ns
ΔV (3U)	> 500 m/s
Isp	> 1000 s
Thrust	> 0.5 mN
Power consumption	< 10W full system pref. < 5 W thruster
Propulsion system wet mass	< 550 g
Total propulsion system size	< 9.5 cmx9.5 cmx5 cm

These requirements meet the Customer needs and will provide a quick-to-market disruptive technology that can be effectively scaled up to larger platforms

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

Technology verification target

HiperLoc-EP Target Verification Performance						
Thrust density mN/cm^2	Specific Impulse (sec)	Specific Thrust mN/kW	Thrust target µN	Volume dm^3	Thruster Efficiency %	Total Impulse (Ns)
0.2	> 1000s	≥ 56	≥ 500	n/a	50	2000

Notes

- Specific impulse is tuneable, higher Isp is possible but this will increase cost
- Thrust density is not a driving system requirement
- Thrust level is geared towards perceived market rather than a limiting factor
- Total Impulse can be varied, and is perceived as a market enabler

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

Novelty

- New approach driven by requirement for major cost reduction
- Radical paradigm shift in the manufacturing and materials used for any EP system (including colloid)
- The design is an integrated system comprising
  - Colloid thrust head
  - Propellant Storage and Feed System
  - Power Processing Unit

HiperLoc-EP test piece

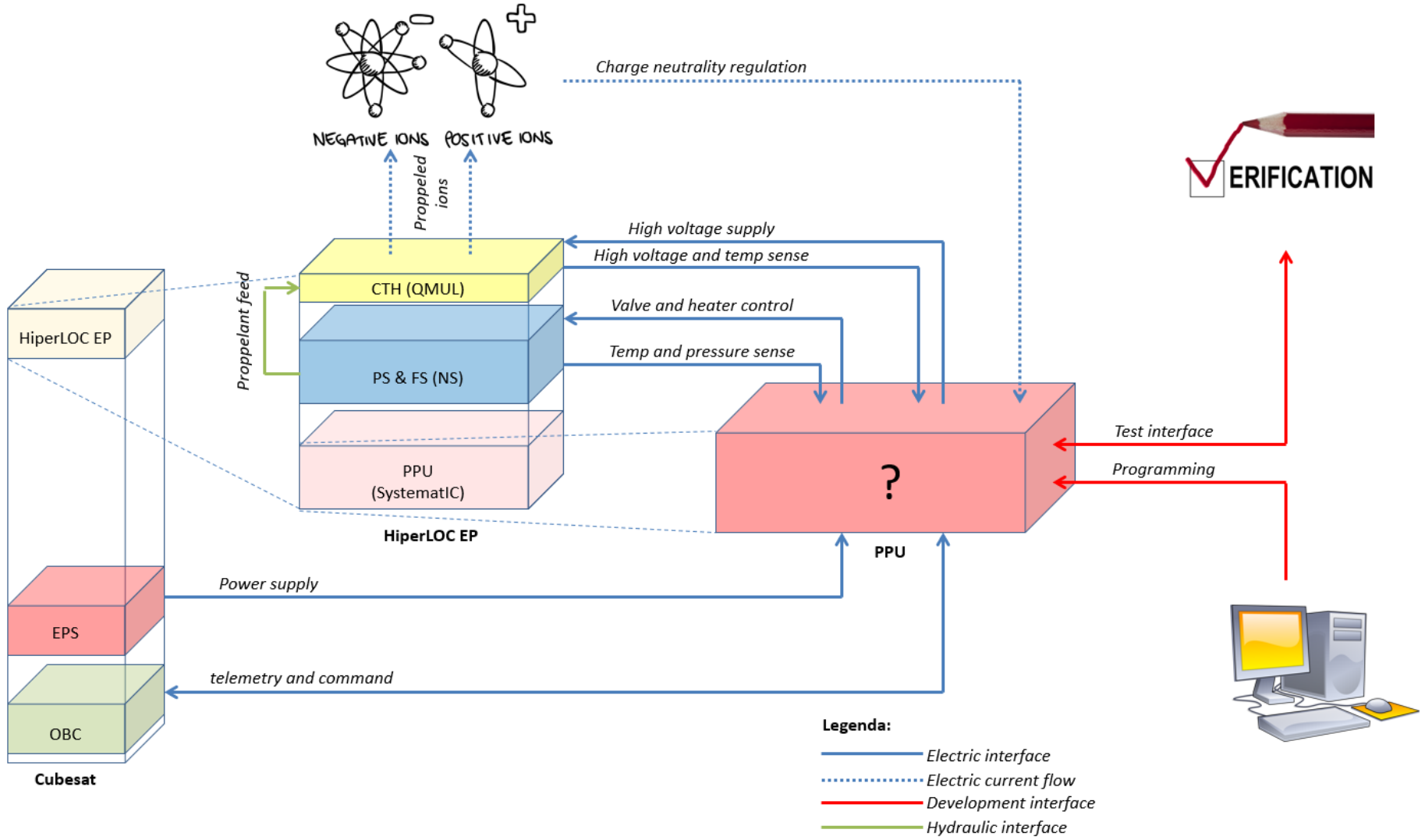
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

Activities Completed

- Website on line http://www.hiperloc.eu/
- Analysis carried out:
  - ✓ markets disruption by HiperLoc-EP Technology
  - ✓ functional requirements
  - ✓ system performance requirements
  - ✓ Component testing
- Design of Bread Board Model
  - ✓ System architecture
  - ✓ Sub-system detailed design
- Manufacture of Bread Board Model
  - ➢ Mainly completed with some iteration following early tests
  - ➢ Initial BBM integration undertaken

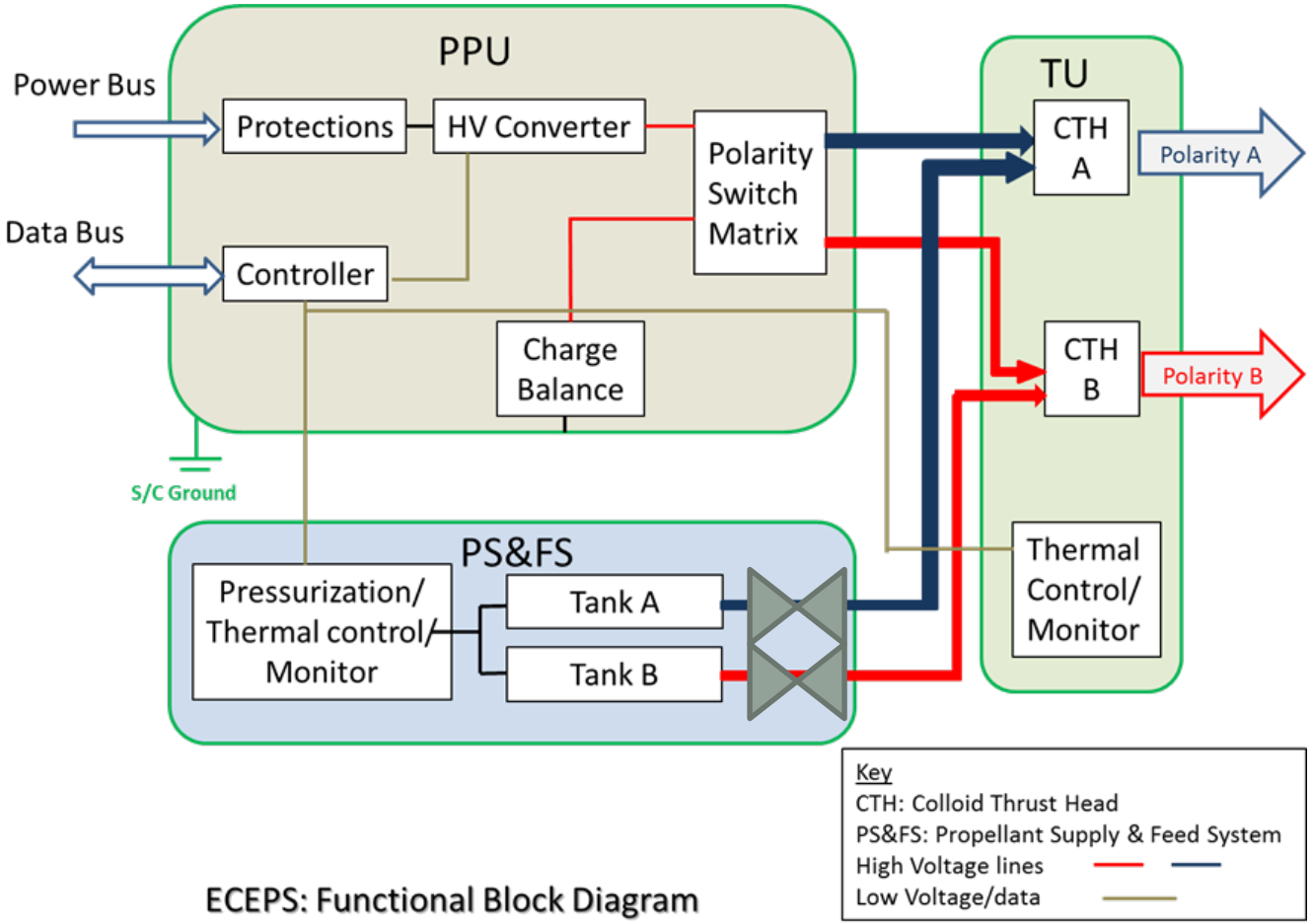
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

Targeted Solution



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

System Highlights In More Detail

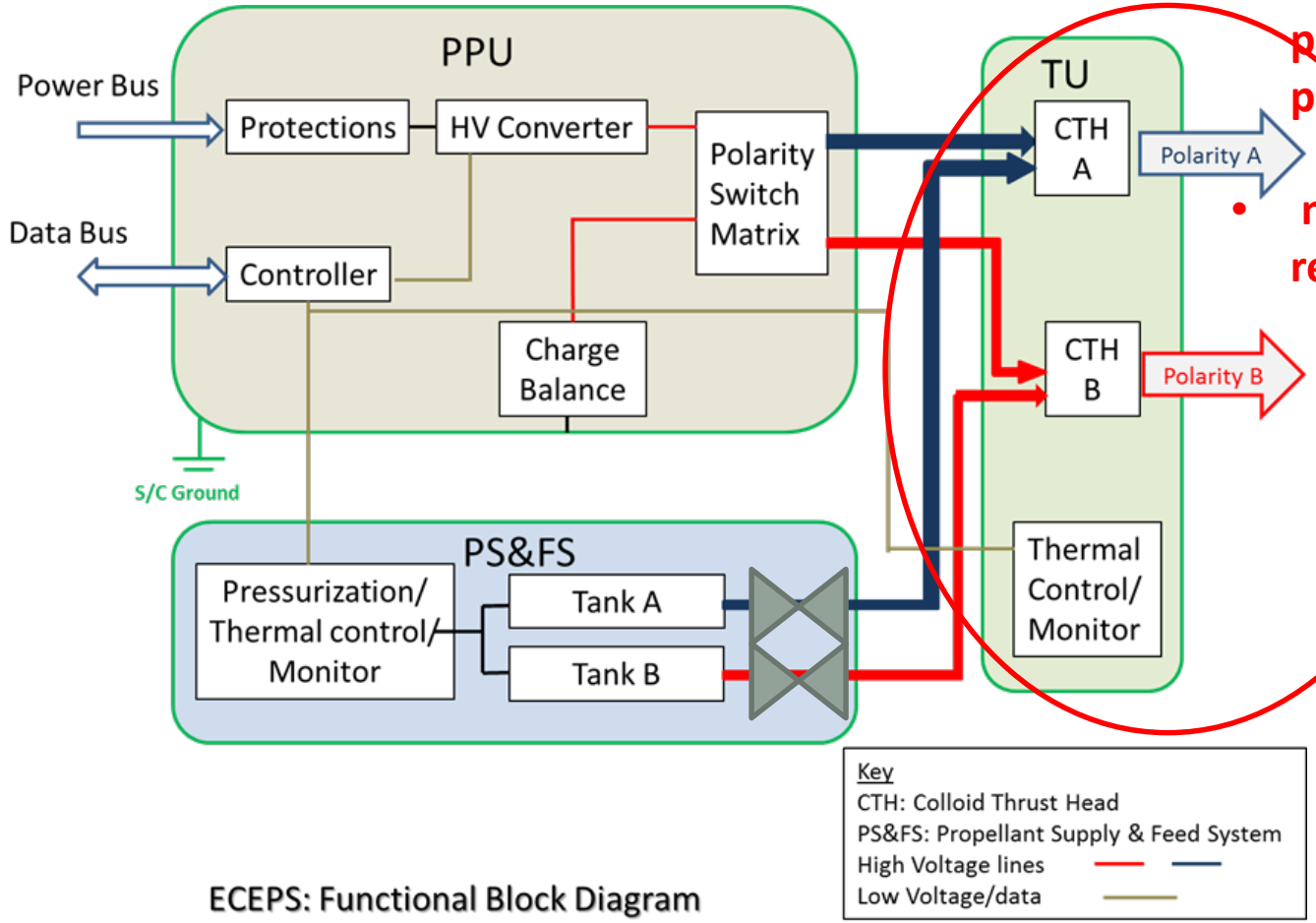


ECEPS: Functional Block Diagram

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

System Highlights In More Detail

- All propellant and power is used propulsively:
- no neutralizer required

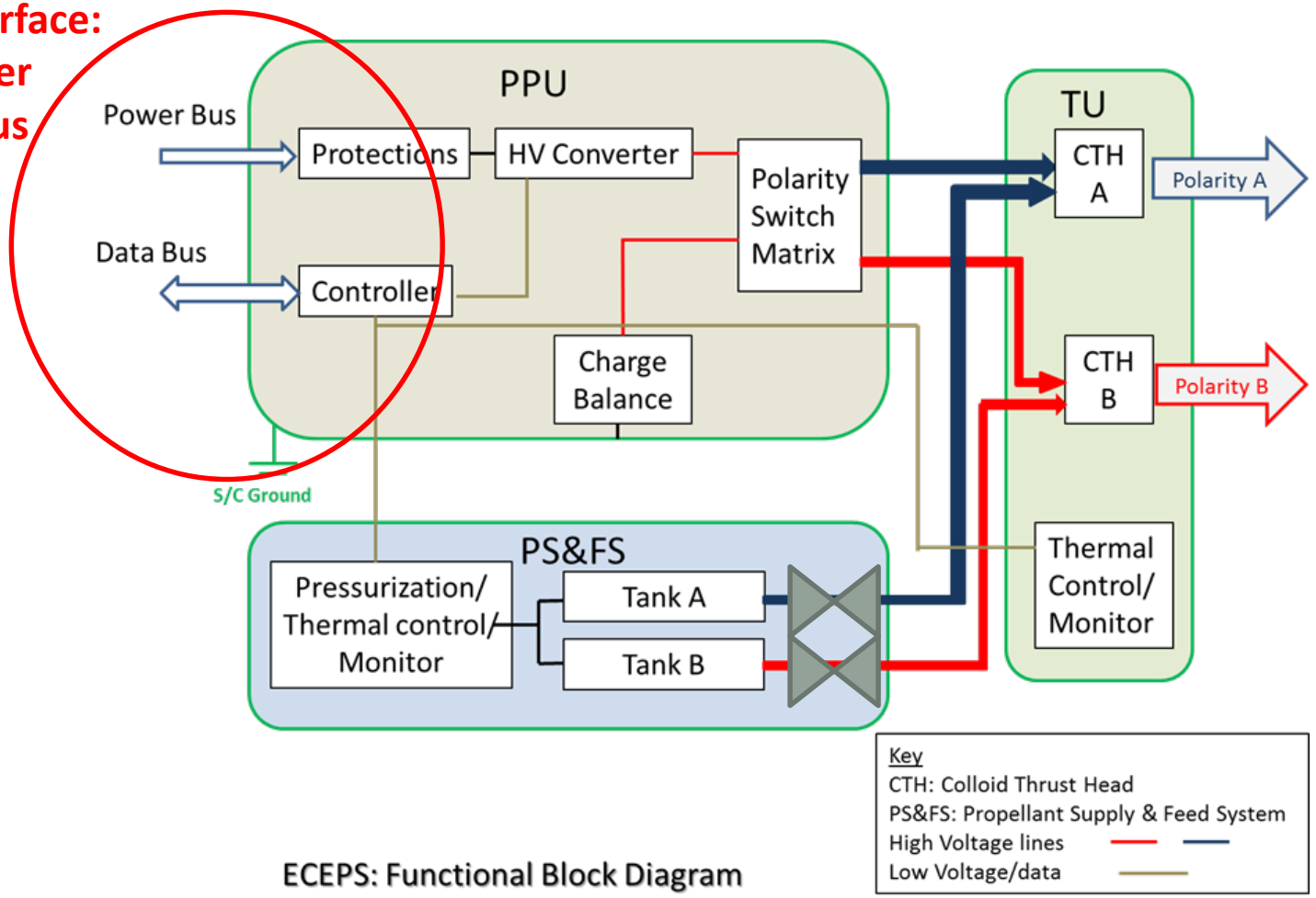


ECEPS: Functional Block Diagram

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

System Highlights In More Detail

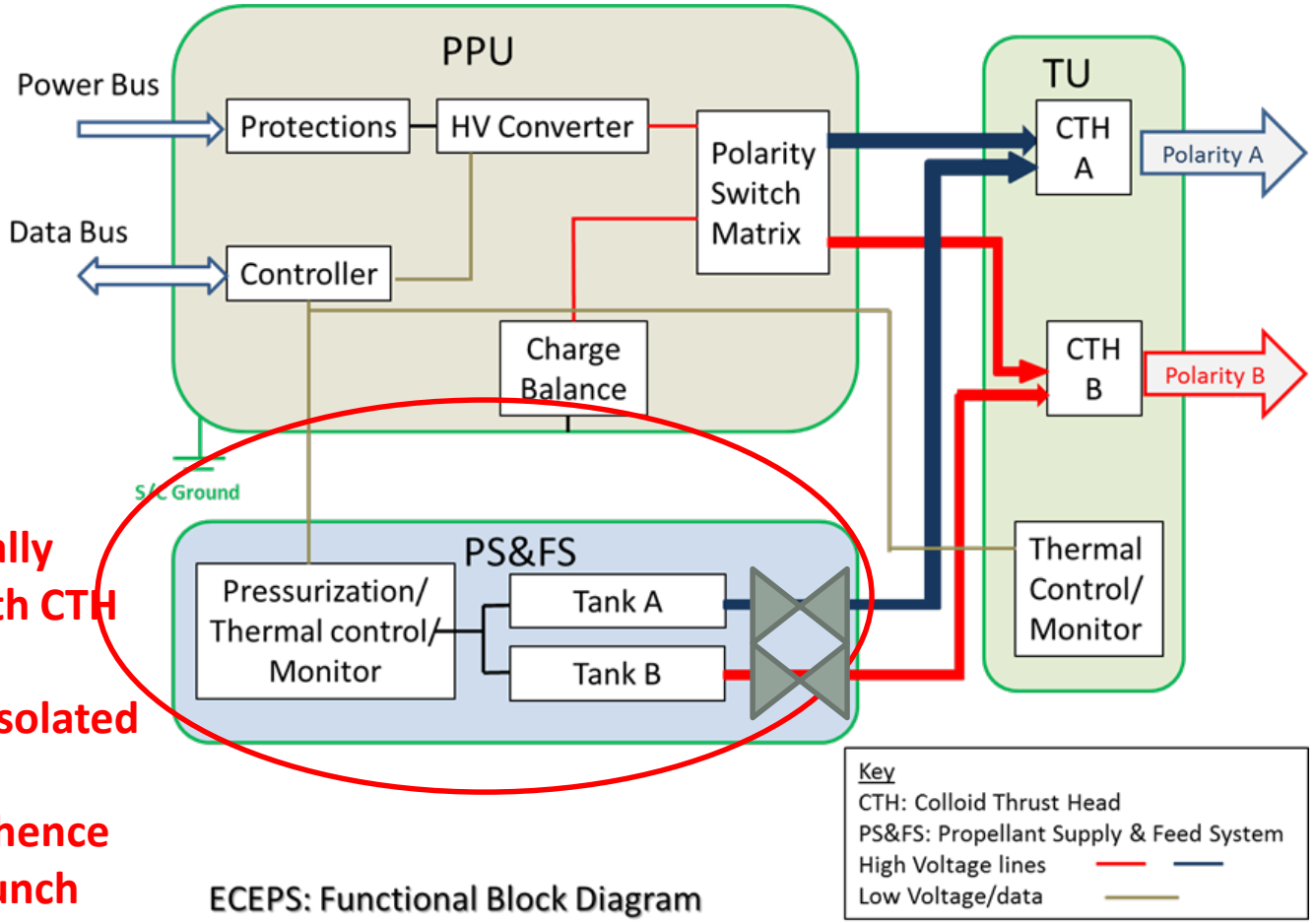
- **Simple interface: only a power and data bus**



ECEPS: Functional Block Diagram

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

System Highlights In More Detail

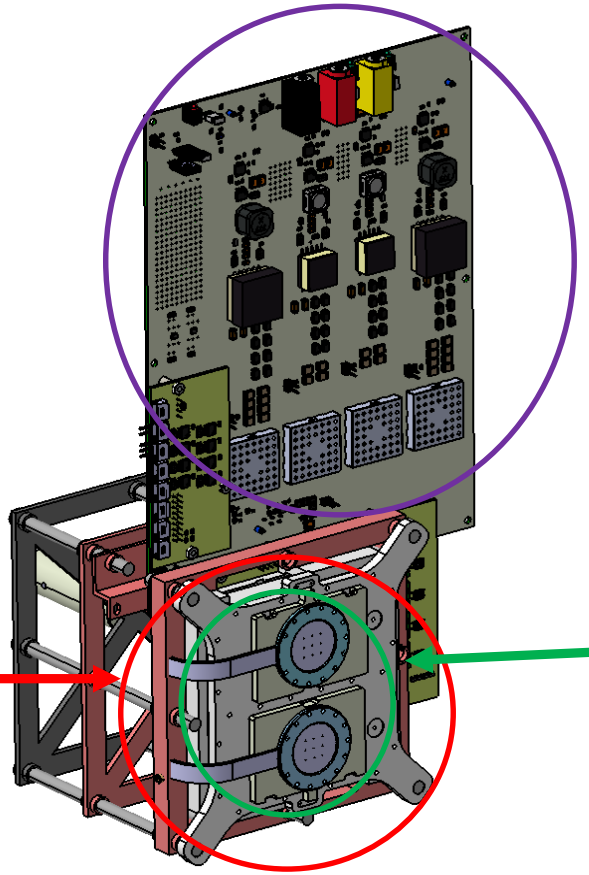


ECEPS: Functional Block Diagram

- **PS&FS thermally integrated with CTH and PPU**
- **Propellant is isolated from ground environment hence simple pre-launch storage**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

Bread Board Model design features



PPU: 2 PCBs, not constrained by CubeSat geometry

Propellant supply and feed system (PSFS) integrated behind CTH

Fully integrated colloid thrust head (CTH), with PSFS

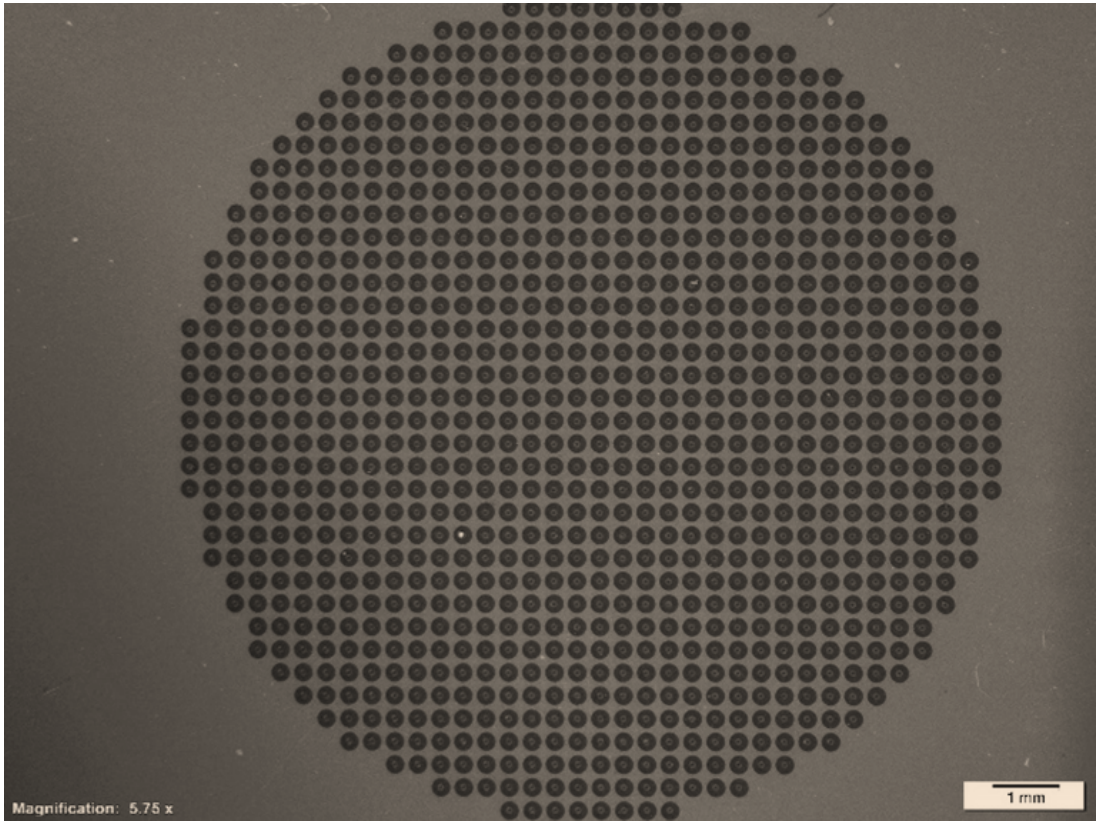
Full BBM design

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

What makes HiperLoc EP
High performance Low cost

Colloid Thruster Head

- Scaling of the thrust while maintaining efficiency
- Cost reduction with innovative manufacturing techniques
- CTH fully integrated with both PSFS and PPU
- **Image:** single polarity CTH with required number of emitters to meet the verification target of >500µN

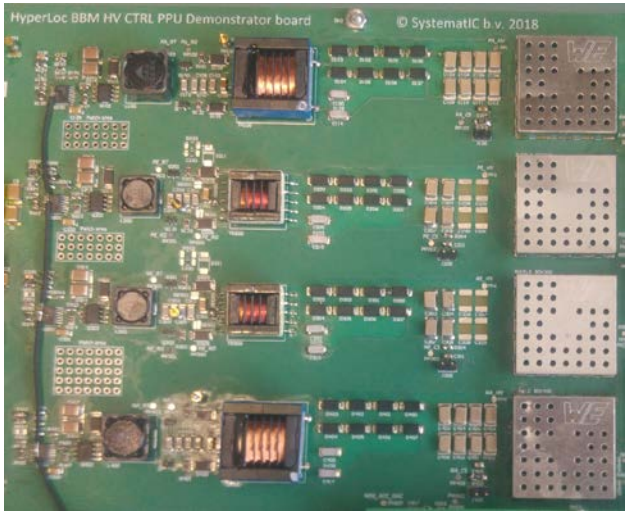


This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

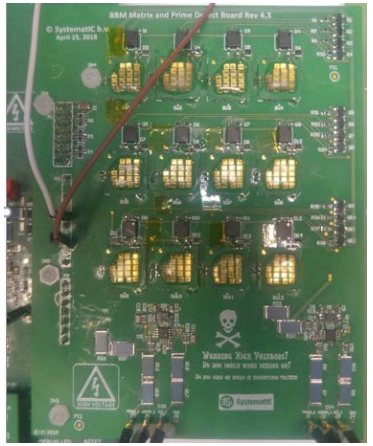
What makes HiperLoc EP High performance Low cost

Power Processing Unit

- Efficient HV generation at low power
- Cost reduction by using COTS
- Volume reduction by:
  - Compact architecture
  - Component count



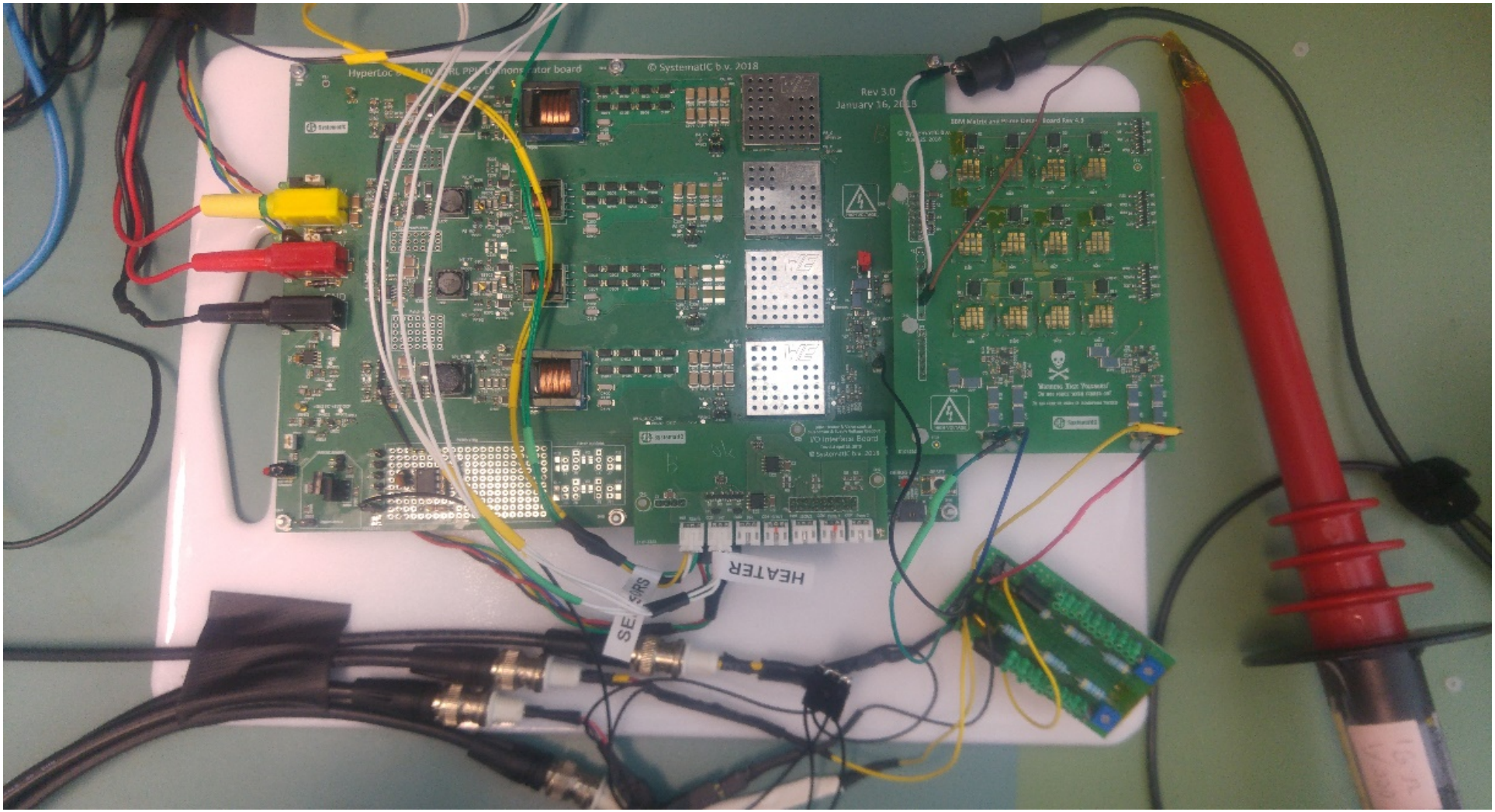
PPU HV Generation & Control board



PPU Switch Matrix Board

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

Full PPU BBM under test



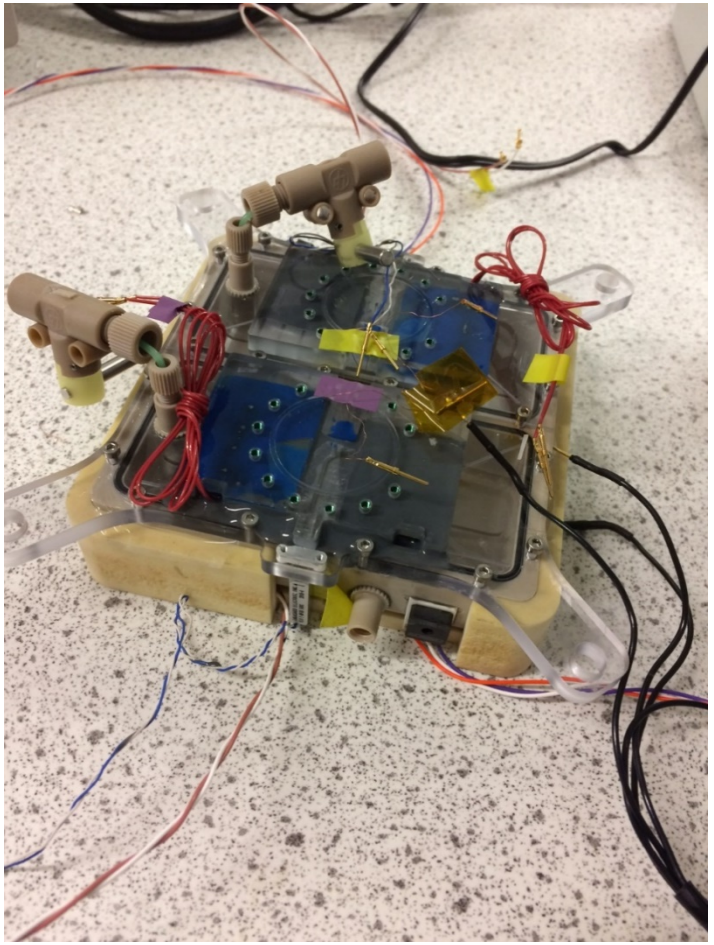
PPU BBM connected to an electric model of the CTH and PS&FS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

What makes HiperLoc EP High performance Low cost

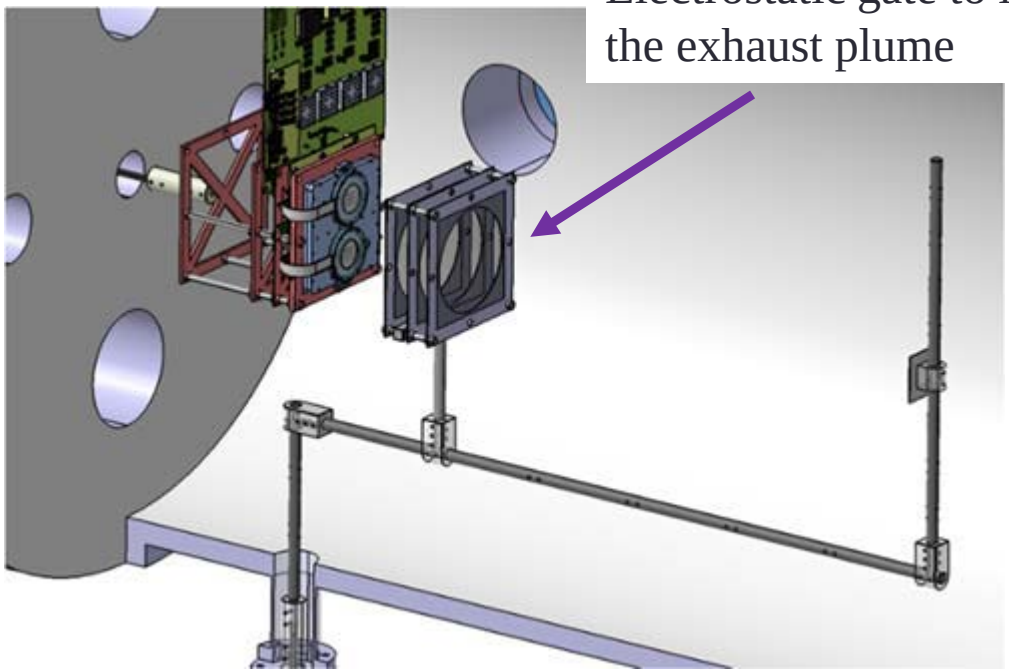
Propellant Supply & Feed System

- Integrated fully with CTH: propellant tank lid also provides base for CTH
- Simple pressurization system for propellant flow control
- Cost reduction by using COTS
- **Image**: PSFS during pre-assembly check out



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

BBM Validation



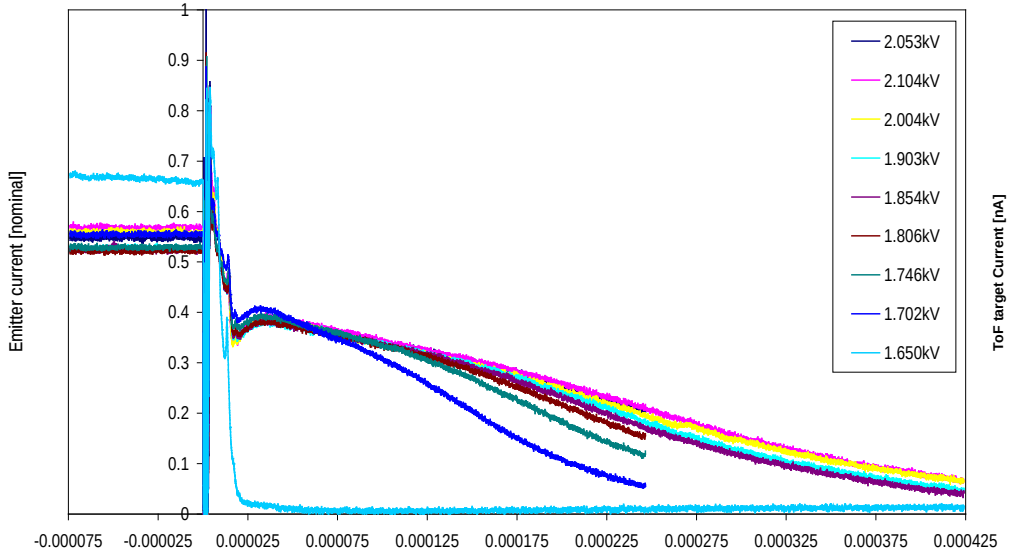
By project completion

- BBM fully characterized
- Design of the thruster unit updated to be flight representative

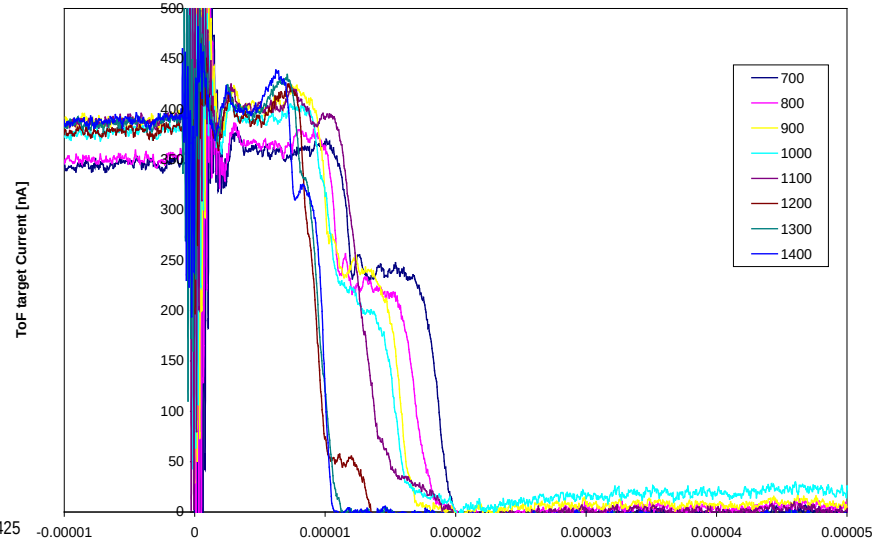
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

Verification of performance

Time of flight is a critical test of specific impulse performance and derived thrust. Obtained by using electrostatic gate of exhaust plume from thruster and measuring the decay current



Low specific impulse (high droplet %)

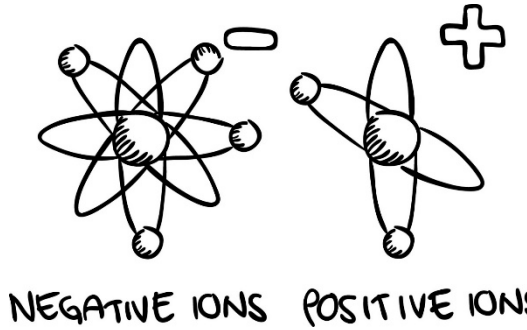


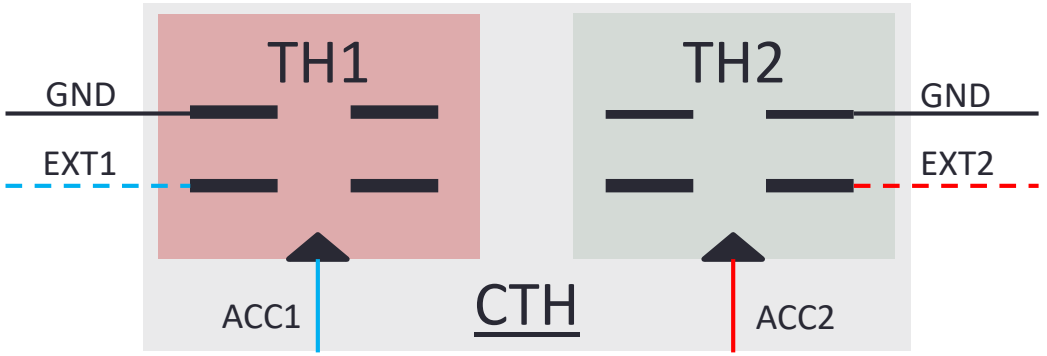
High specific impulse (high ion%)

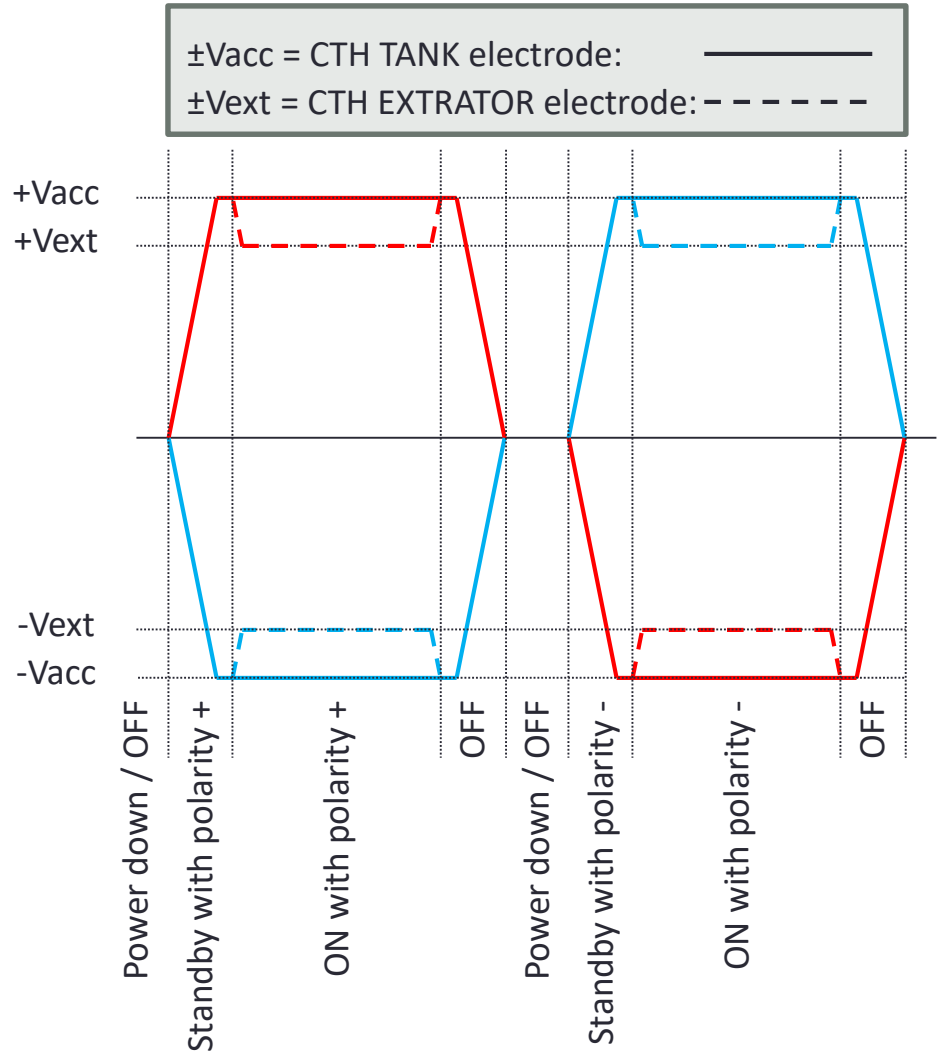
Operating mode is controlled by system hydraulic impedance

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

Thruster head control

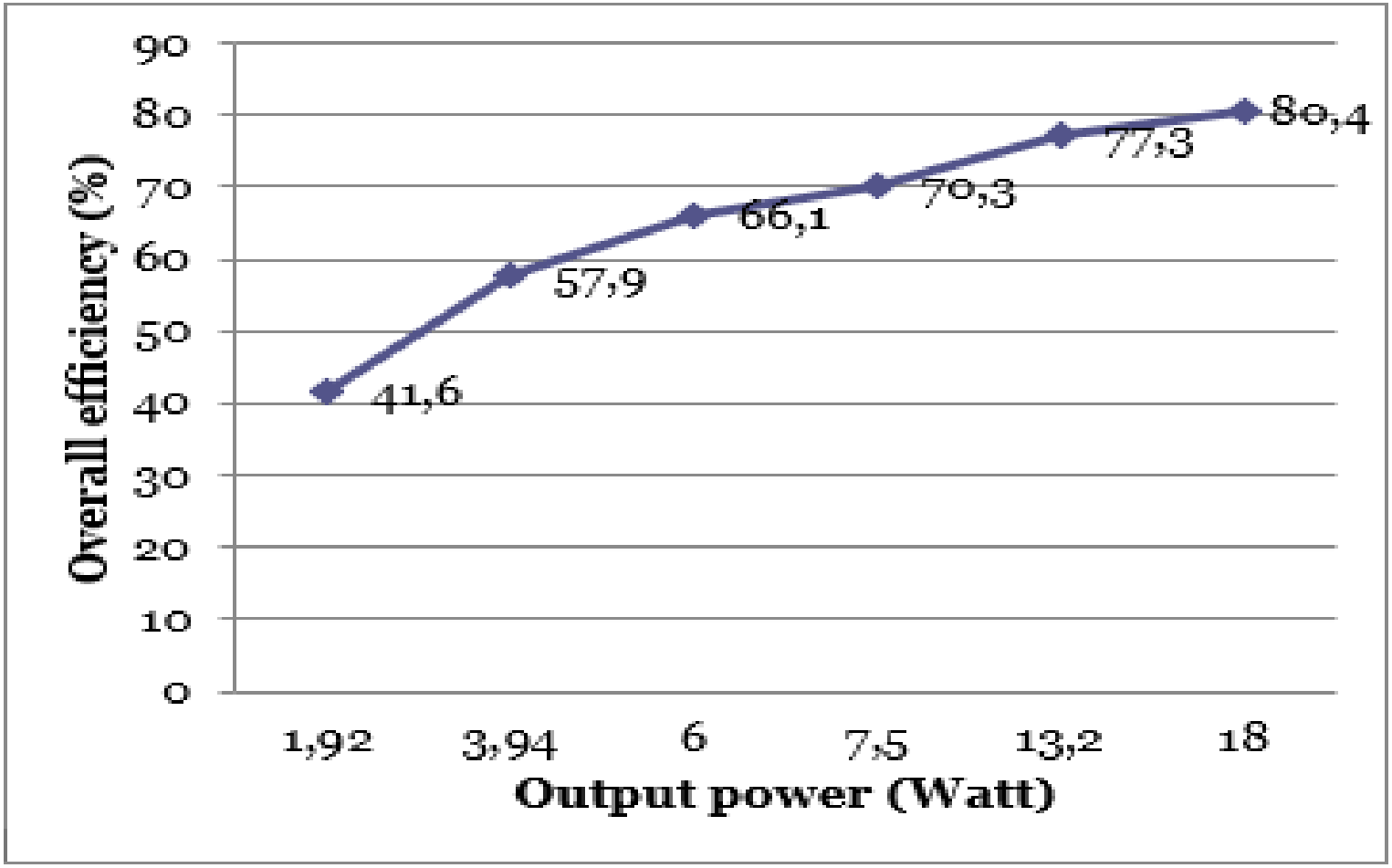






This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

Measurement of Conversion Efficiency



Efficiency versus output power

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

Conclusions

- High efficiency: No neutralizer required
- HiperLoc-EP provides a radically different way to achieve the advantages of an electrospray colloid electric propulsion system
- The paradigm shift in manufacturing approach will result in an improved performance to cost ratio by an order of magnitude
- Hence anticipate HiperLoc-EP system will prove to be disruptive to markets adopting multi-unit CubeSats and with potential for new market mega-constellations of small satellites

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075

THANK YOU

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730075