comat
INSPIRED BY SPACE

Space propulsion May 2022

Plasma Jet Pack SP2022

Summary

- Company overview
- Plasma Jet Pack overview & achievements
- Plasma Jet Pack product & next steps

Plasma Jet Pack

Company overview : space equipment since 1977

105

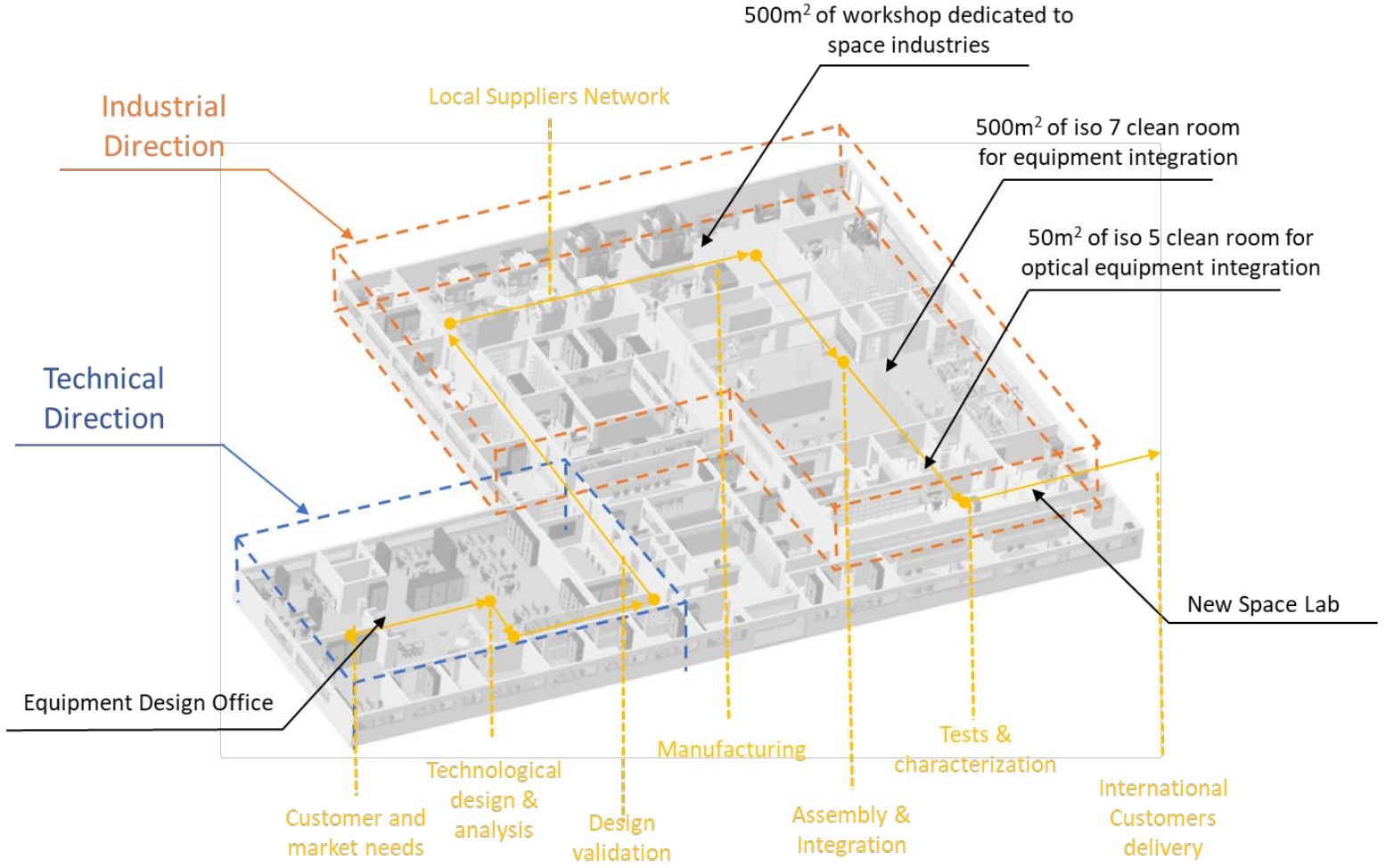
2021: turnover 10,5M€

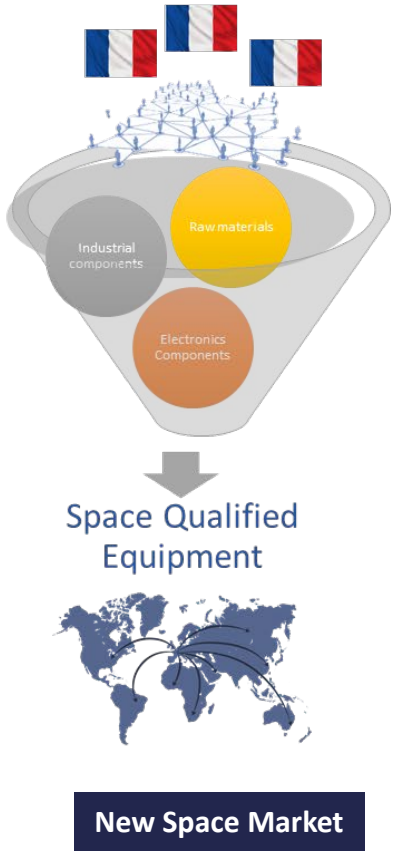
1800 m²
Toulouse Facilities

500 m²
AIT Area, including ISO 5 / ISO 7 room

1000 m²
Manufacturing and control area

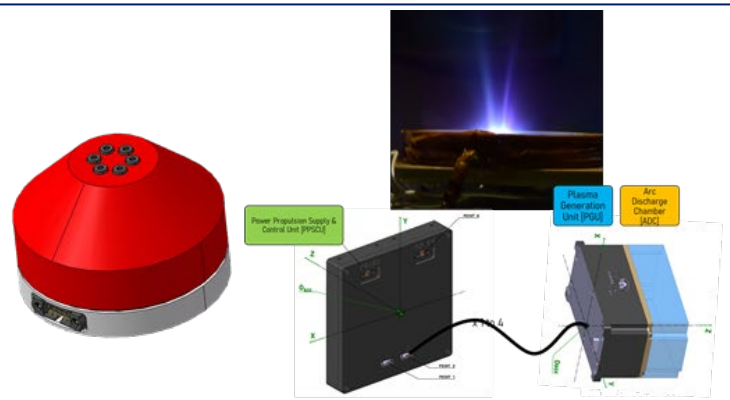
Company overview : space equipment since 1977

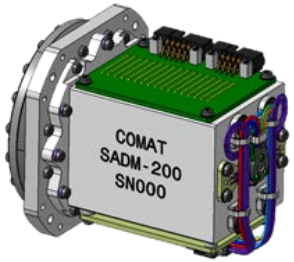




Market & vision

- Four products lines :





1. Reaction wheel

- Reaction Wheel 20mNms ×4
- Reaction Wheel 40mNms ×120
- Reaction Wheel 60mNms ×4
- Reaction Wheel 180mNms ×10

2. Pulse Plasma

- Plasma JetPack 30W with solid propellant ×2
- Plasma JetPack 80W with solid propellant

3. Rotary Actuator

- Solar Array Drive Mechanism 200W ×6
- High Torque Actuator

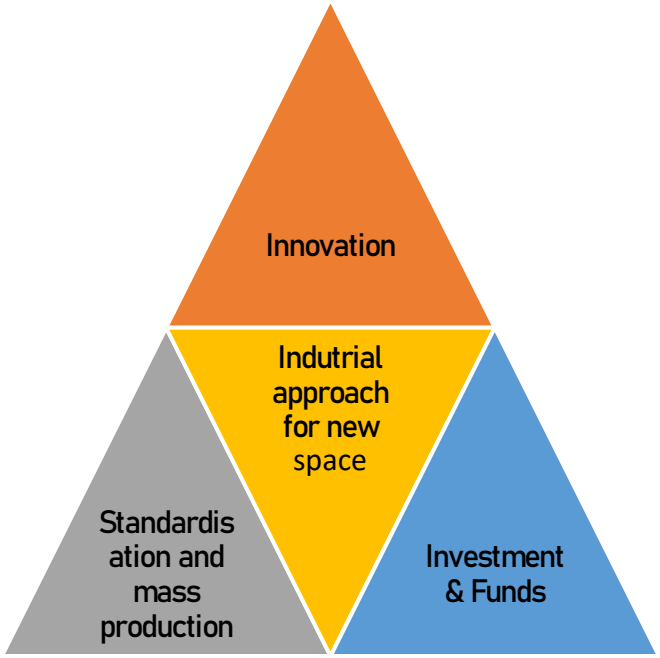
4. Appendages

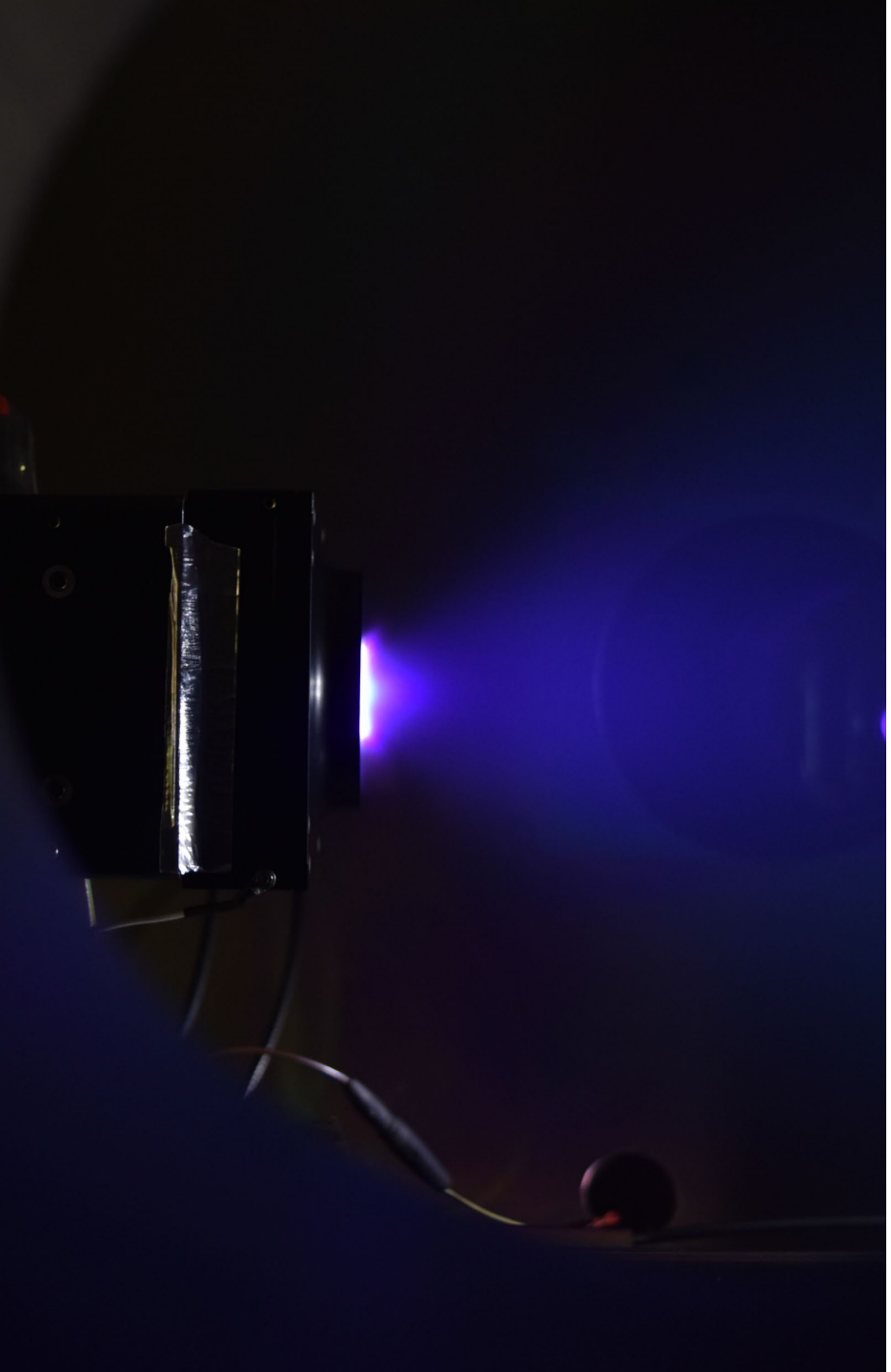
- Deployable Antenna on Kineis Constellation ×25
- Deployable Solar Array

Comat supply chain are designed to deliver hundreds products per year

Market & vision

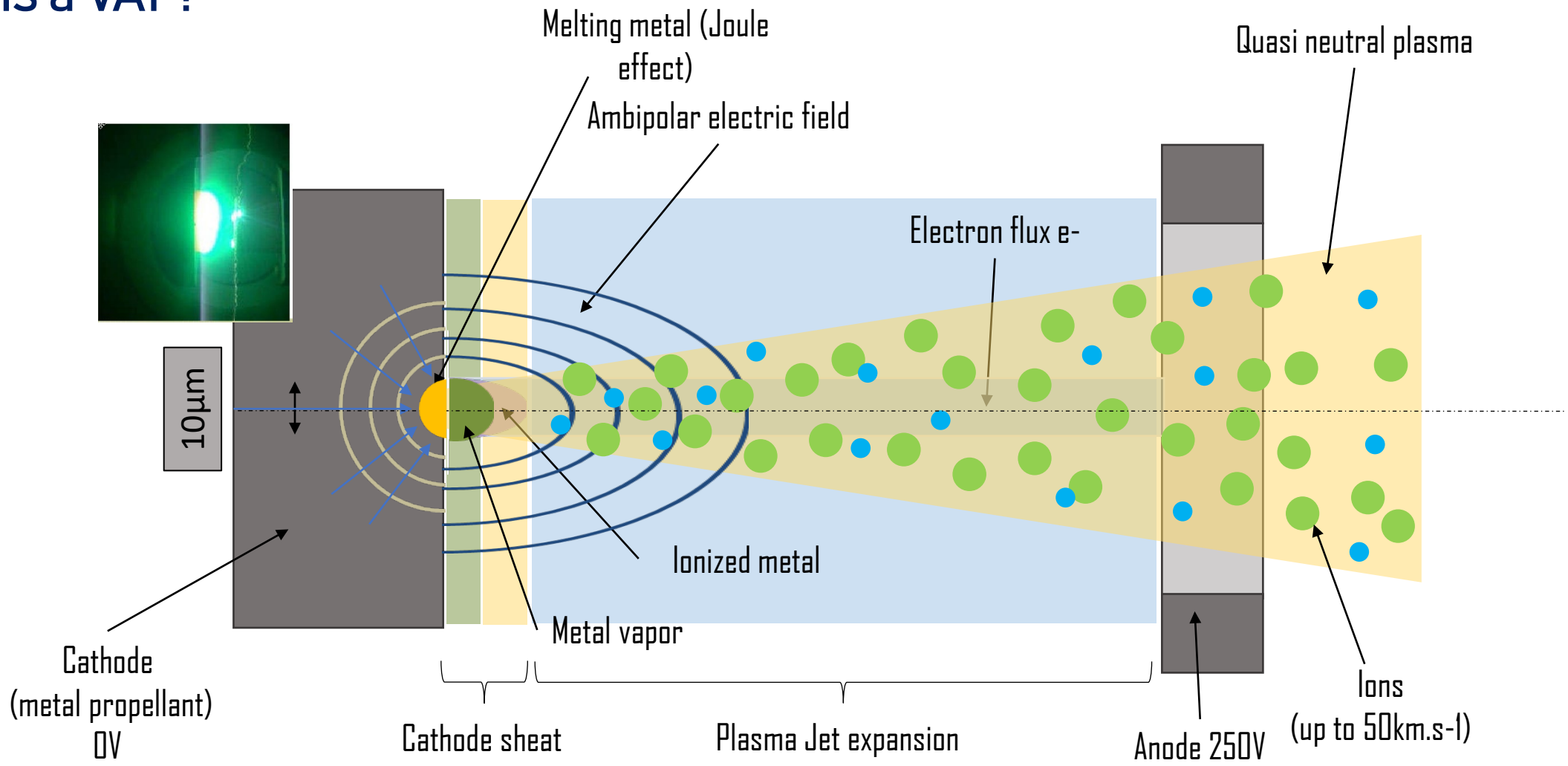
- **Technology building blocks and components**
  - All our products are based on validated building blocks approach
  - All our building blocks are based on adapted industrial components
- **Scalability**
  - The building blocks approach allow to have a quicker expansion of our products families



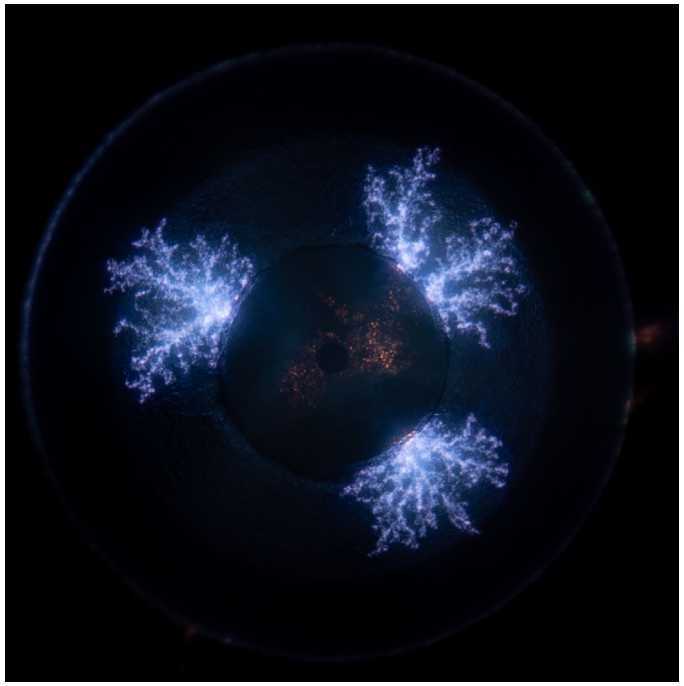


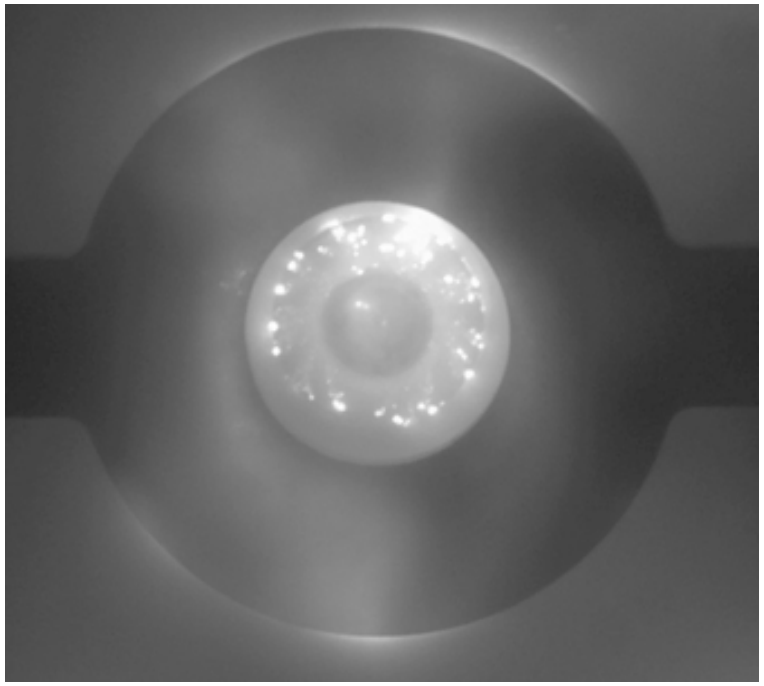
Plasma Jet Pack Overview

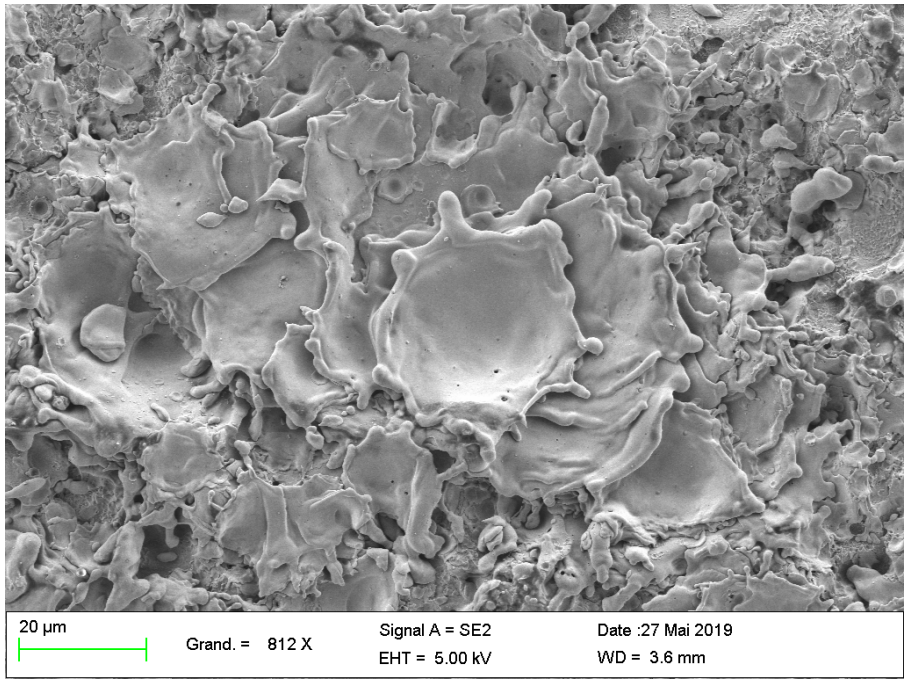
What is a VAT ?


Melting metal (Joule effect)
Ambipolar electric field
Quasi neutral plasma
Electron flux e-
10µm
Ionized metal
Metal vapor
Cathode
(metal propellant)
0V
Cathode sheat
Plasma Jet expansion
Anode 250V
Ions
(up to 50km.s-1)

Cathode spots investigation:

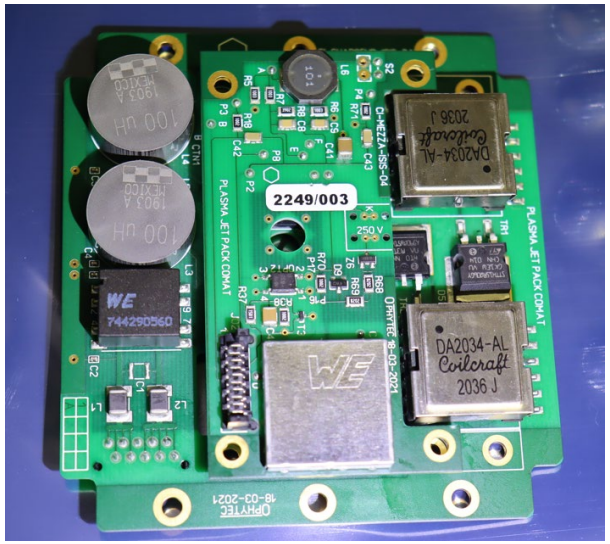


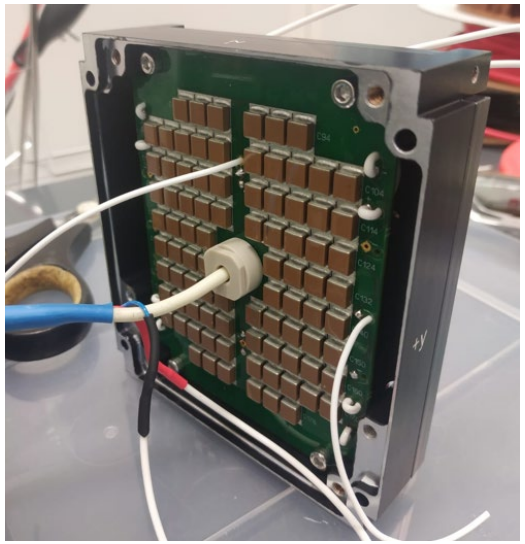


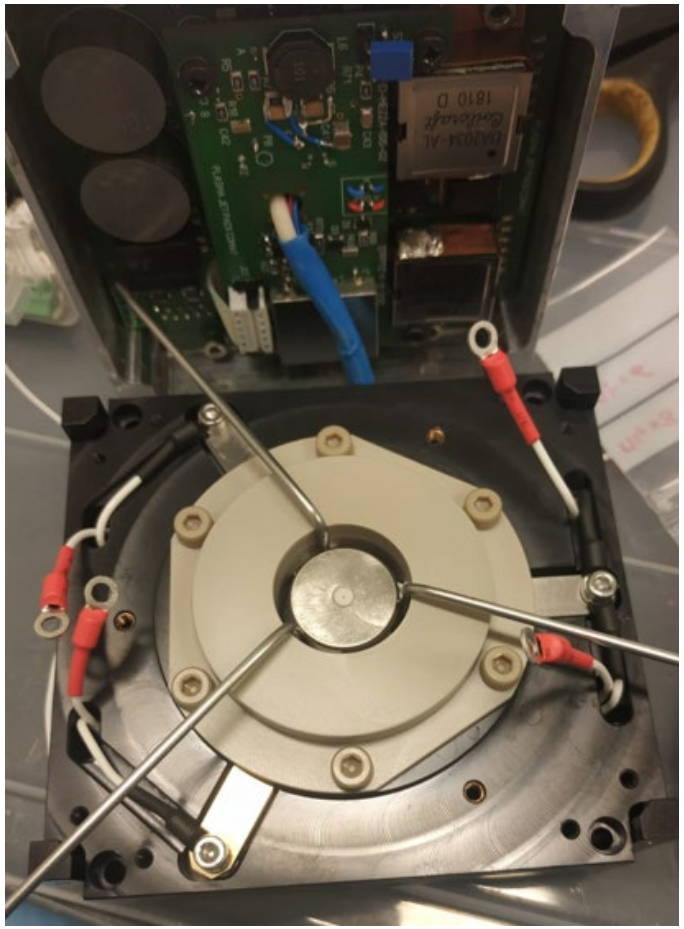


- Fractal structure of the spots
- Spots located close to the ignitor
- More than 100 cathode spots per pulses
- Spot's craters diameter between [1-50µm]

PJP Hardware:



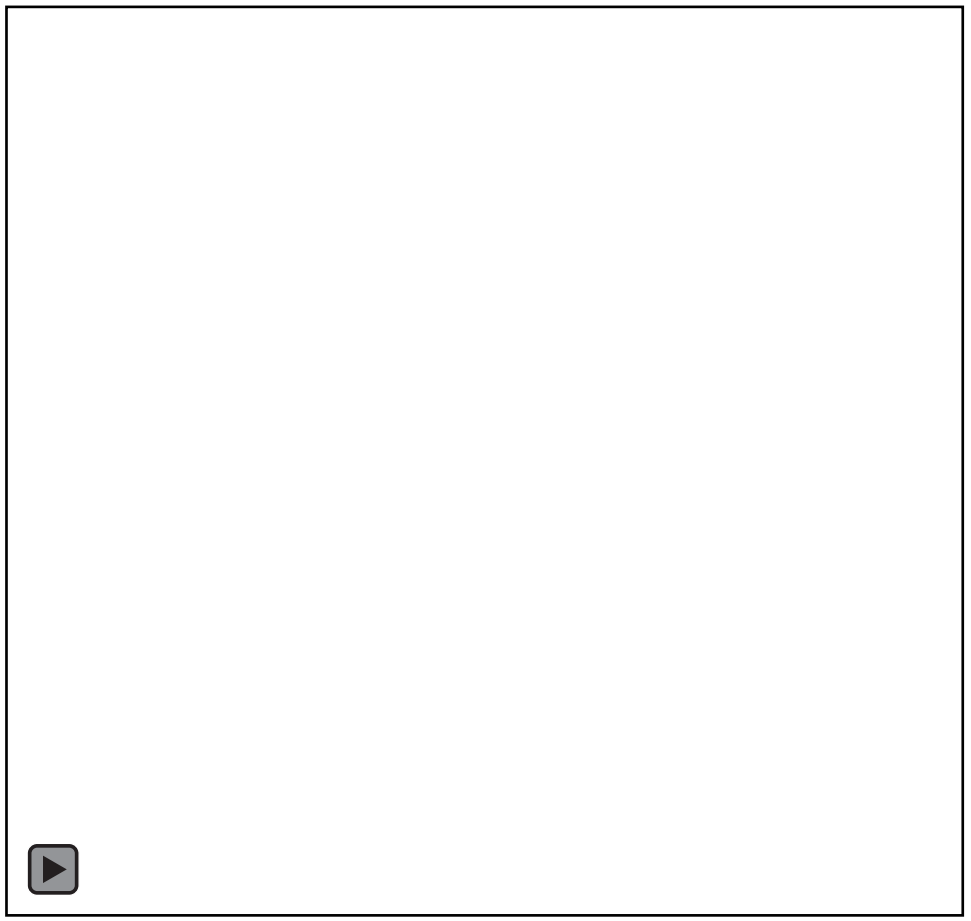




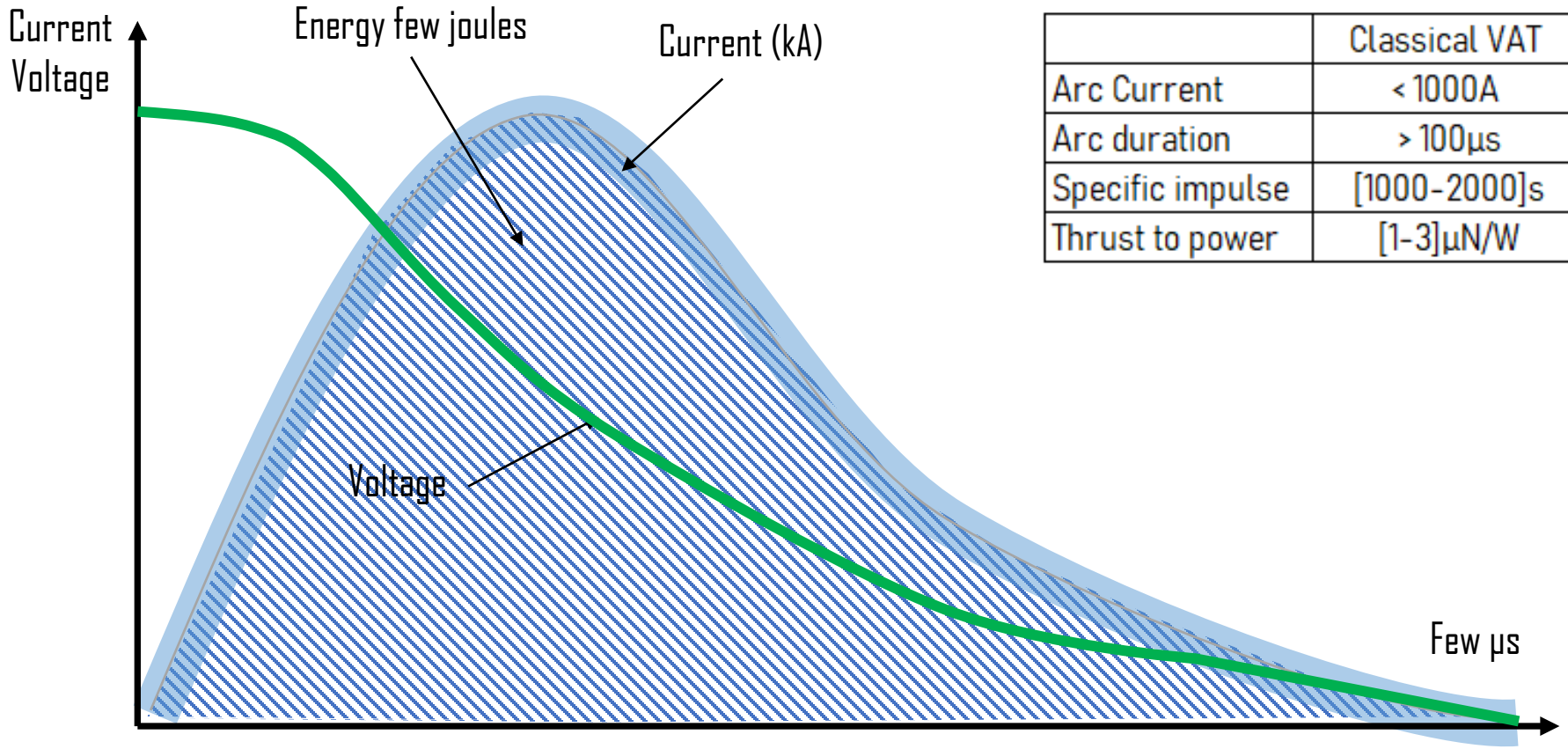
Plasma Jet Pack

BBM5 – 2017

BBM6 – 2019



PJP: High current / short duration Vacuum Arc Thruster



	Classical VAT	PJP
Arc Current	< 1000A	> 2000A
Arc duration	> 100µs	< 30µs
Specific impulse	[1000-2000]s	> 2000s
Thrust to power	[1-3]µN/W	[3-10]µN/W

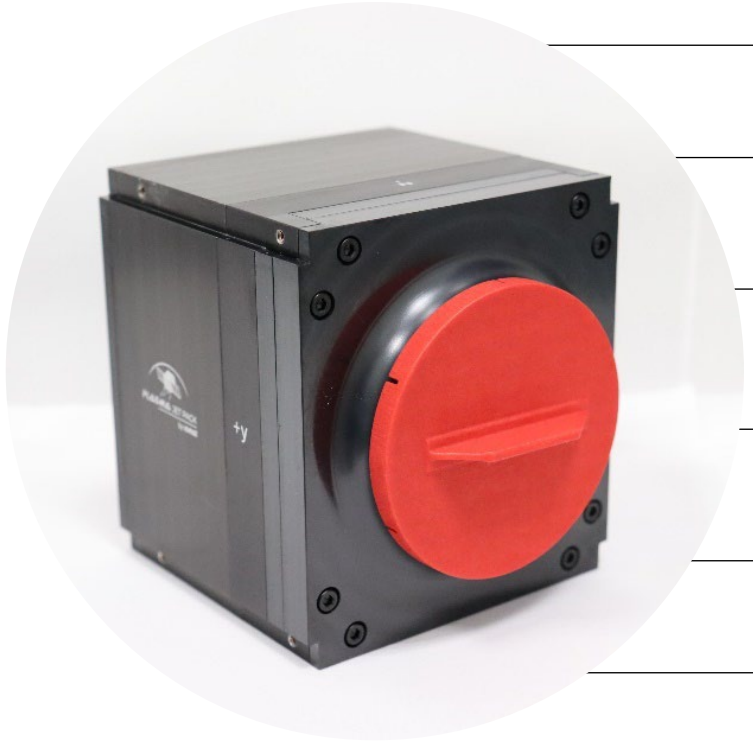
Market position

✓ Technical:

- Solid Metal propellant / high density
- On-demand thrust
- Vectorized thrust
- Thrust adjustable as function of frequency
- plug & play product

✓ Commercial:

- Itar free technology



Safe

=> high density propellant

Small volume

=> high density propellant

Low cost

=> Basic architecture

Environment friendly

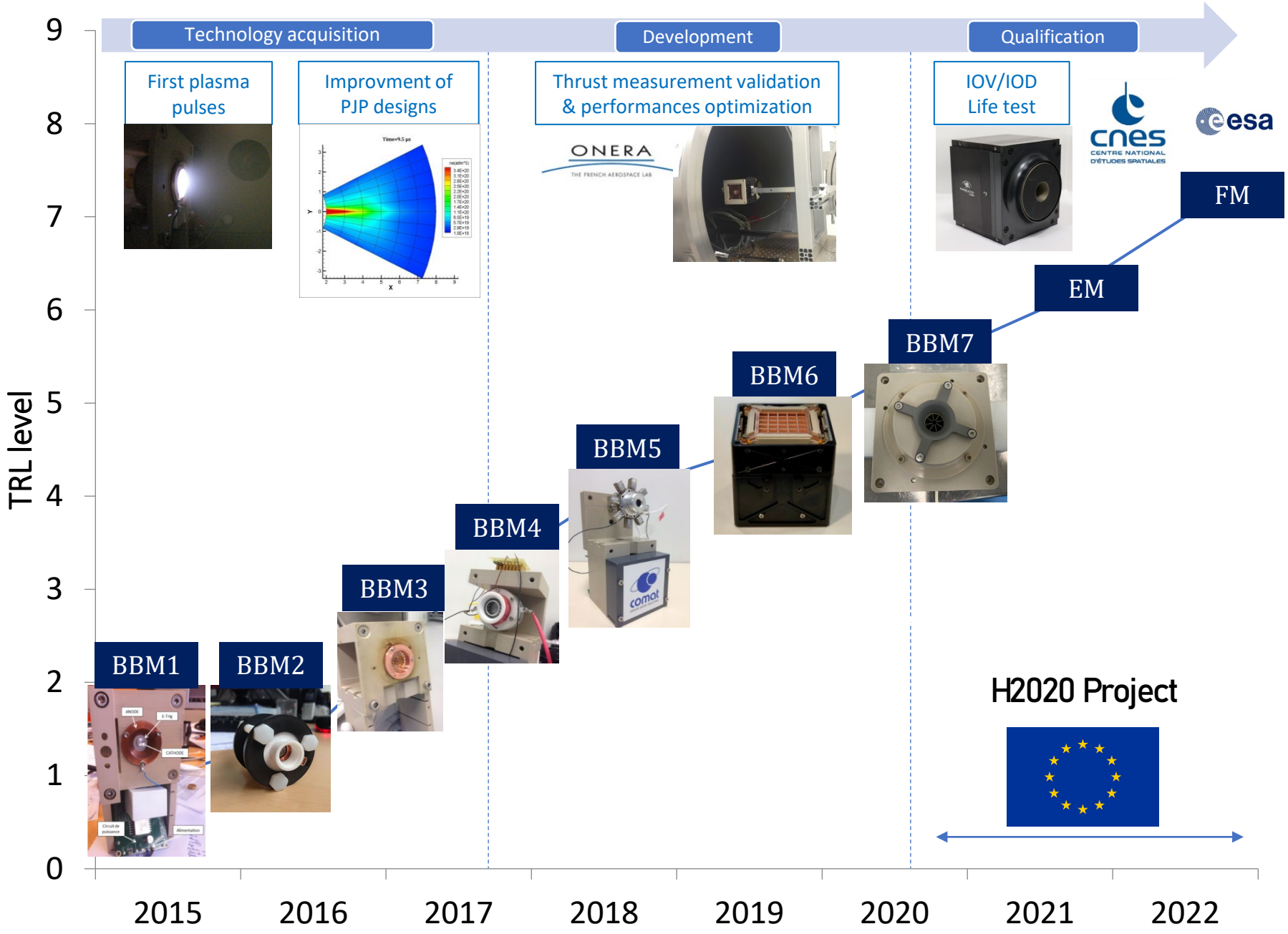
=> inert solid metal propellant and ROHS process

ITAR free

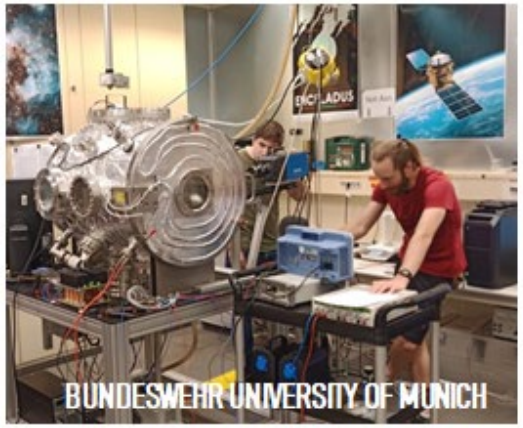
=> use of COTS

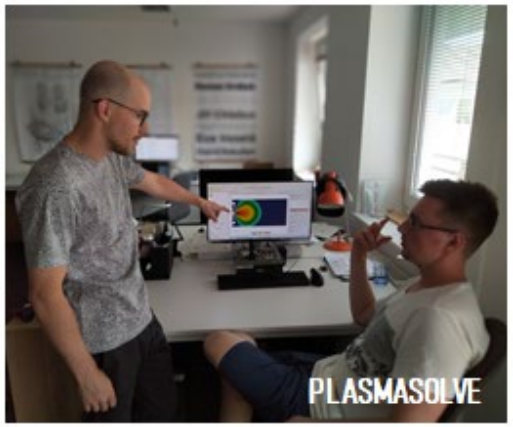
Adapted to low power

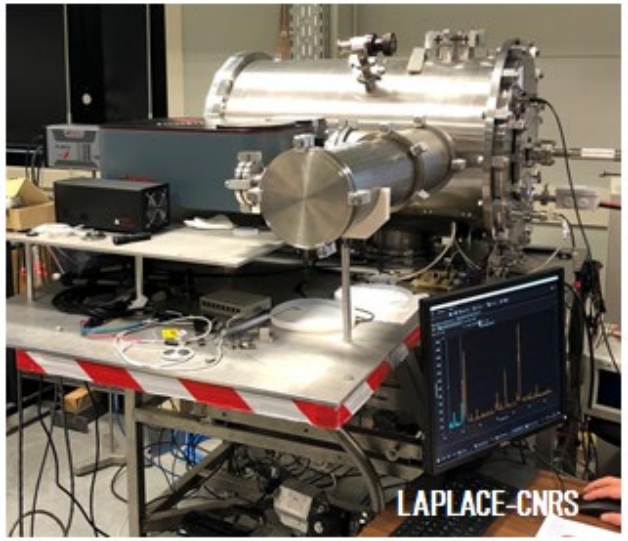
=> pulsed plasma thruster


Technology acquisition
Development
Qualification
First plasma pulses
Improvment of PJP designs
Thrust measurement validation & performances optimization
IOV/IOD Life test
ONERA
THE FRENCH AEROSPACE LAB
cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES
esa
FM
EM
BBM7
BBM6
BBM5
BBM4
BBM3
BBM2
BBM1
comat
H2020 Project
TRL level
0
1
2
3
4
5
6
7
8
9
2015
2016
2017
2018
2019
2020
2021
2022

Technical consortium H2020 project:







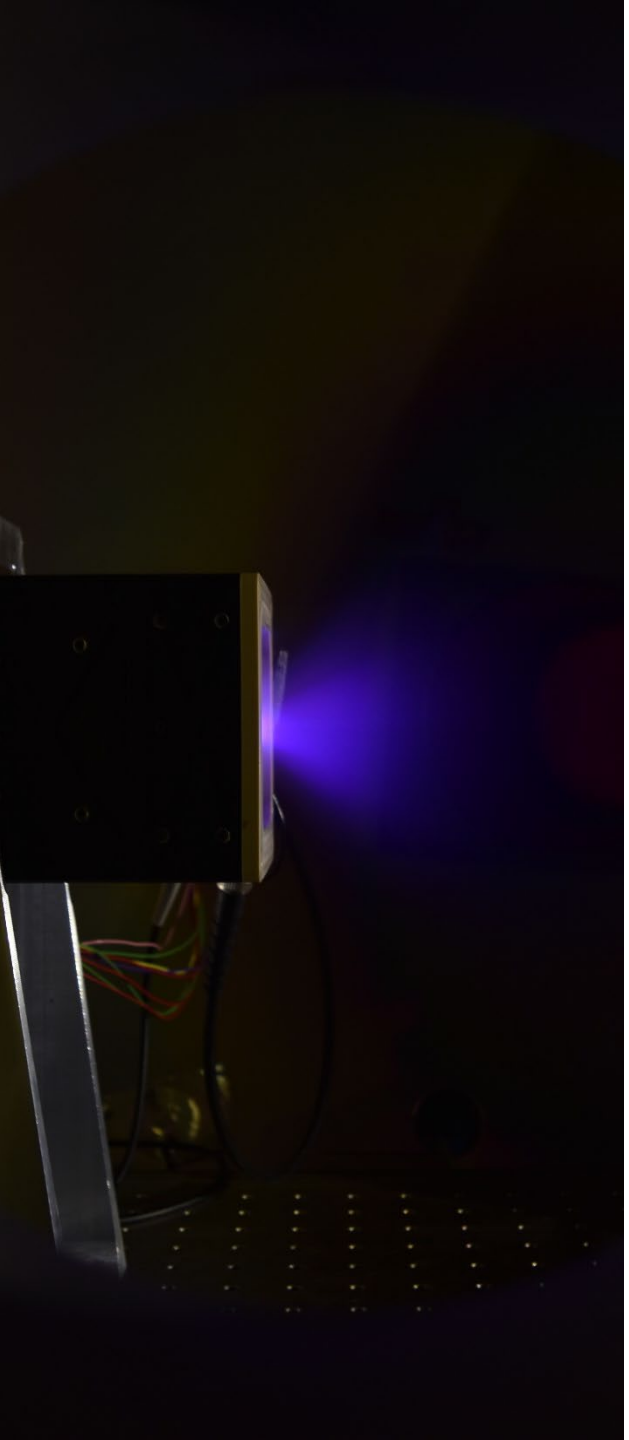
Main results of the H2020 project and conclusions:

Plasma parameters:

- $v_i = [15, 50]$ km/s (higher than classical VATs)
- At least 2 ions populations (fast and slow / spark and arc regime)
- Ion density follow the arc current dynamique
- $T_e =$ [1,6] eV in the arc regime
- Up to Ti8+ species
- Z ~ 2 Mean ion charge Ti
- Macroparticles tracking – 60m/s – 0 to 10% of the mass ejected depending on the cathode material

Magnetic nozzle:

- Increase the thrust/ion velocity up to 1.6 times.
- Focus of the plasma bulk on the axis
- Elongation of the plasma plume
- Reduce the ion jet spreading (increase of the pulse to pulse repeatability)
- May cause reduction of the ignition (electron short cut from the anode)
- Need a low residual magnetic moment
- High magnetic field needed

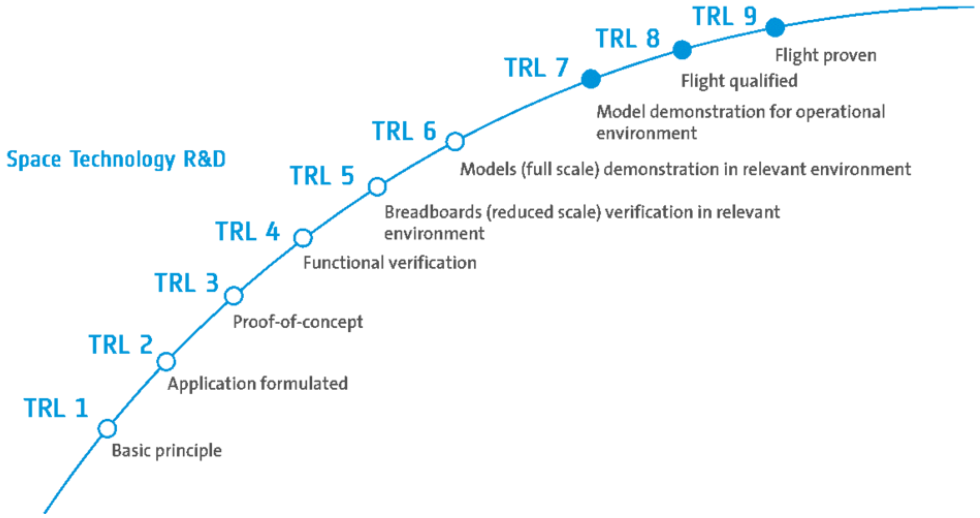


PJP product architecture

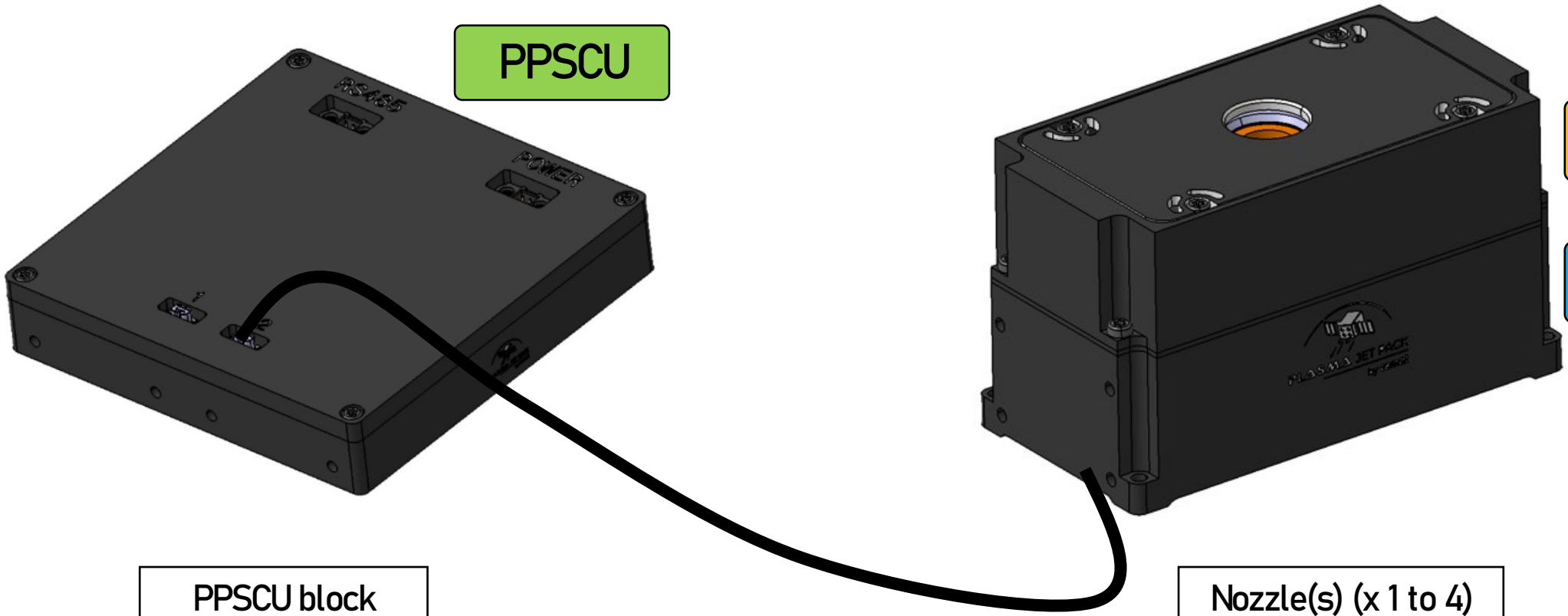
Plasma Jet Pack

Building Blocks

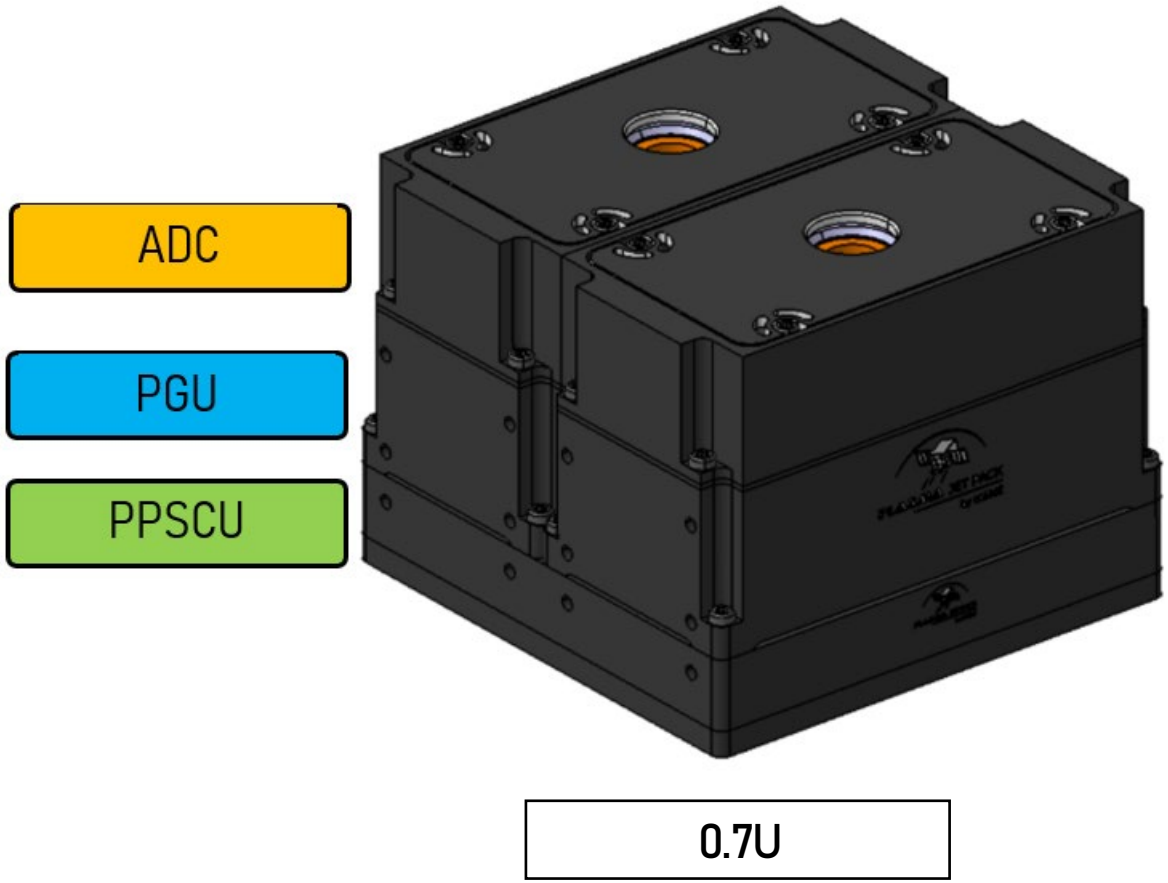
Arc Discharge Chamber [ADC]	Plasma Generation Unit [PGU]	Power Propulsion Supply & Control Unit [PPSCU]	Housing & Satellite Interface [HSI]
TRL 4	TRL 6	TRL 5	TRL 5



Product architecture (deported version):



Product architecture (pluggable version):



0.7U

Face	+Z	+Z	-Z	-Z
Nozzle number → SIN ↓	1(D)	2(D)	3(PD)	4(PD)
1	NC	NC	NC	D
2	NC	NC	D	NC
3	NC	NC	D	D
4	NC	D	NC	NC
5	NC	D	NC	D
6	NC	D	D	NC
7	NC	D	D	D
8	D	NC	NC	NC
9	D	NC	NC	D
10	D	NC	D	NC
11	D	NC	D	D
12	D	D	NC	NC
13	D	D	NC	D
14	D	D	D	NC
15	D	D	D	D
16	NC	NC	NC	P
17	NC	NC	D	P
18	NC	D	NC	P
19	NC	D	D	P
20	D	NC	NC	P
21	D	NC	D	P
22	D	D	NC	P
23	D	D	D	P
24	NC	NC	P	D
25	NC	D	P	D
26	D	NC	P	D
27	D	D	P	D
28	NC	NC	P	NC
29	NC	D	P	NC
30	D	NC	P	NC
31	D	D	P	NC
32	NC	NC	P	P
33	NC	D	P	P
34	D	NC	P	P
35	D	D	P	P

PJP Characteristics:

	ISIS	Product	
Input Power	0-30	**0-30**	W
Thrust Range	0-120	**0-250**	µN
Max frequency	4	**TBD**	Hz
Specific Impulse	> 2400	**>1600**	s
Impulse bit	30	**TBD**	µNs
Max total impulse	8	**400**	Ns
Overall volume	1	**0.7**	U
Operating temperature	-40/+70	**-40/+70**	°C
Supply voltage	12 - 16	**12 - 16**	V
Overall mass	1	**1.2**	kg
Command interface	RS485	**RS485**	EIA

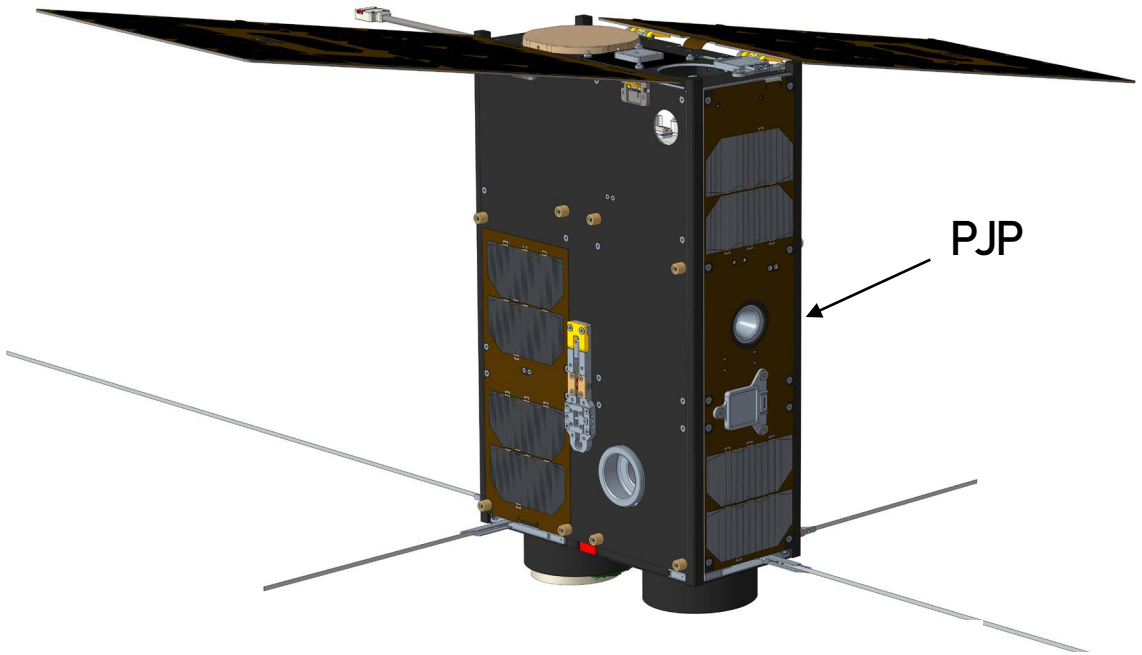
Next steps:

1. AIT of the EM (validation of the new high efficiency PPSCU)
2. Thermal and mechanical validation and justification of the entire module
3. Life test duration (total impulse validation on one nozzle)
4. Qualification tests
5. Validation in orbit (IOD/IOV) with U-SPACE 6U platform - 2023

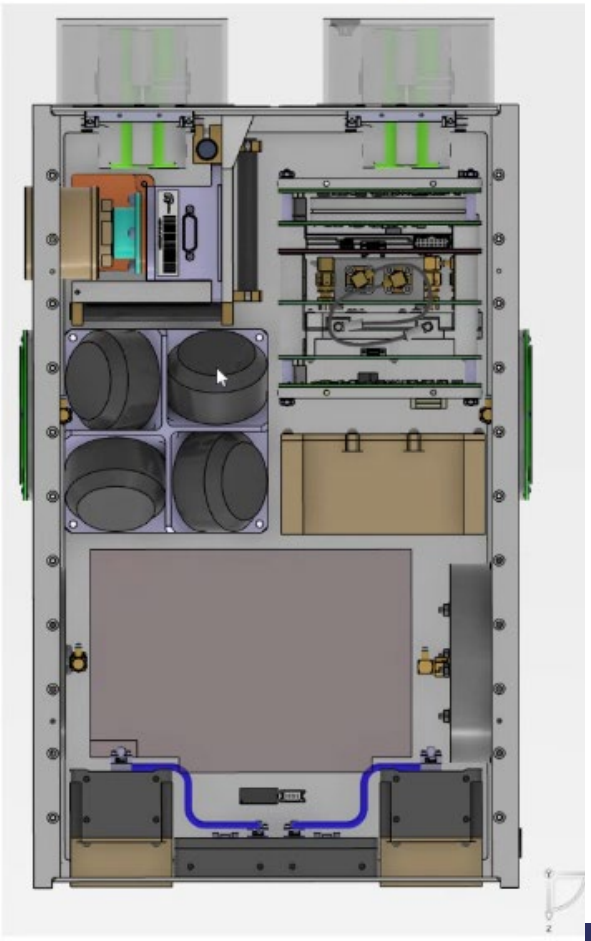
Plasma Jet Pack

IOD/INV ·

ISIS 6U platform – Launch December 2022



USPACE 6U platform – Launch 2023



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Thank you for your attention