Research and Innovation In Actions :
SPACE-13-TEC-2019: SRC-In-Space electrical propulsion and station keeping

comat
INSPIRED BY SPACE

11th May 2023

Plasma Jet Pack Overview EPIC 2023

Summary

May 11,2023

- Comat Overview
- Plasma Jet Pack H2020 project
  - Introduction
  - Physics description
  - Objective 1
  - Objective 2
  - Objective 3
- In-flight demonstration IOD/IOV
  - With HIT
  - WITH ISIS funded by H2020
  - With USpace funded by CNES

Plasma Jet Pack

Company overview : space equipment provider since 1977

105

2022: turnover 12M€

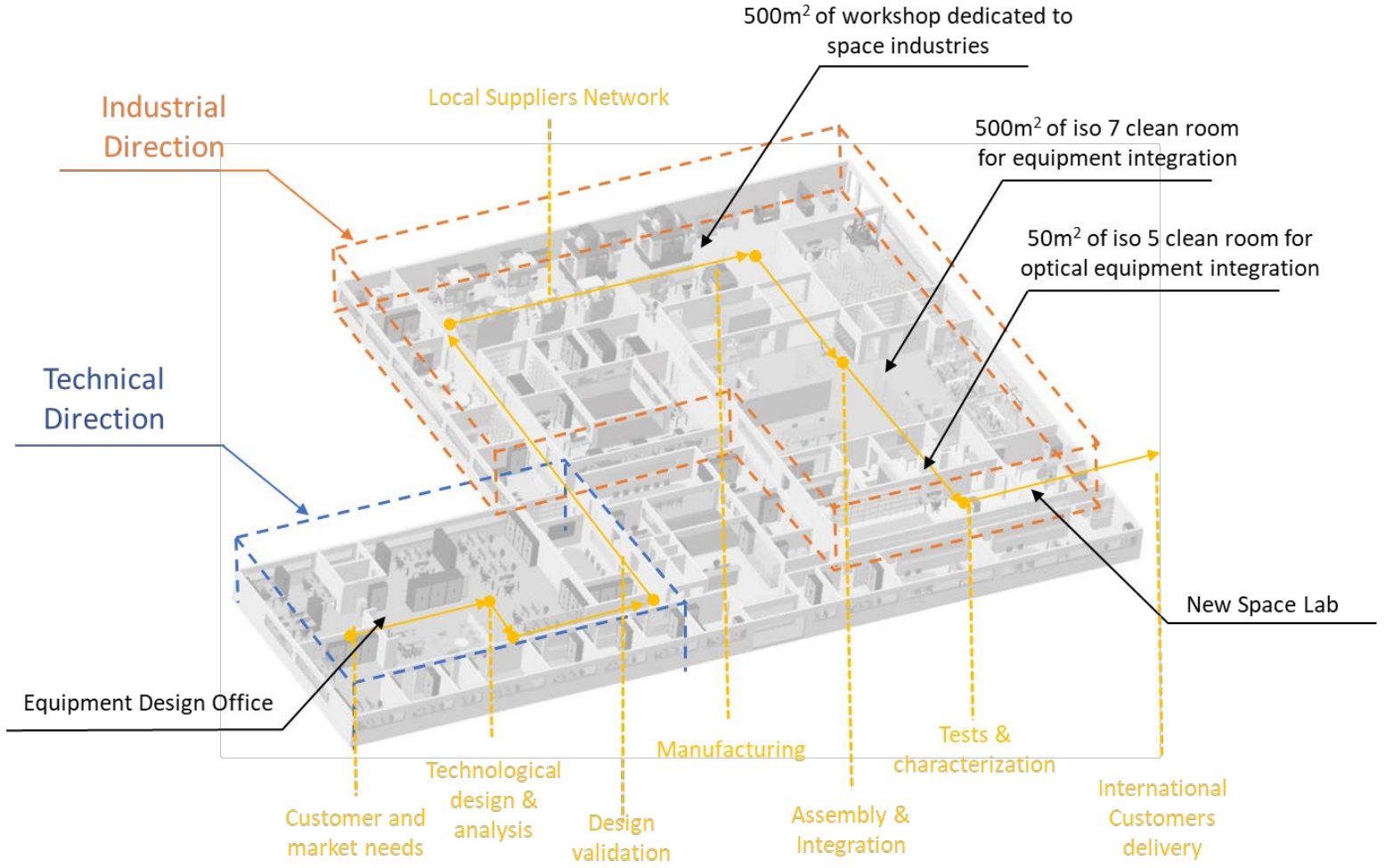
1800 m²
Toulouse Facilities

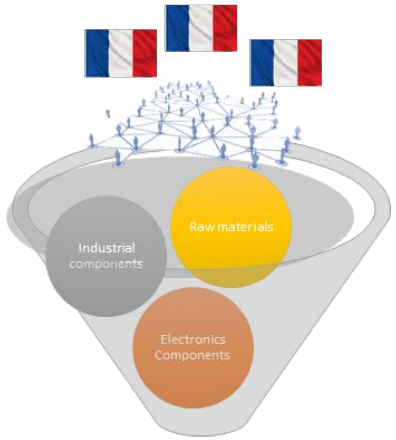
500 m²
AIT Area, including ISO 5 / ISO 7 room

1000 m²
Manufacturing and control area

Plasma Jet Pack

Company overview : integrated company



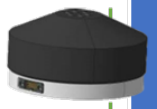


Space Qualified Equipment

New Space Market

Plasma Jet Pack

New Space Market



Platform

Small satellites

Reaction wheel

Reaction Wheel 20mNms x4

Reaction Wheel 40mNms x120

Reaction Wheel 60mNms x4

Reaction Wheel 180mNms x4

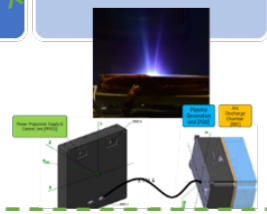
Small satellites

Plasma Jet Pack

Plasma Jet Pack 30W with solid propellant x3

Plasma Jet Pack 80W with solid propellant

Plasma Jet Pack 200W with gas propellant

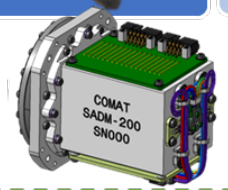


Small satellites

Rotary actuators

SADM (200W) x10

High torque mechanism



Small satellites

Appendices deployables

Antennas x25

Boom

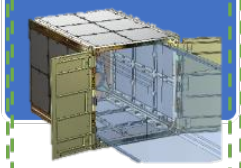
Radiators

Launcher

Small Satellites

Launcher devices

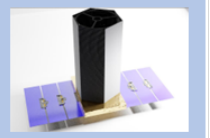
Dispenser : outox



Small Satellites

Optical

High resolution space telescope



Plasma Jet Pack

Market & vision

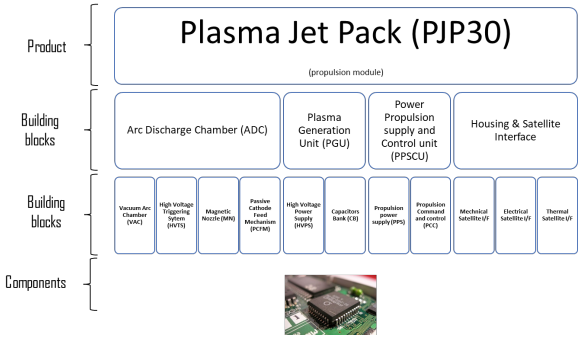
- ✓ The development of commercial missions based on constellations of small satellites (10-150kg) needs to have reliable and long life duration equipment to sustain their business.
  - We have chosen to develop equipment following European Cooperation Space Standardization (ECSS)
  - The qualification of our products are done for 8 years life duration

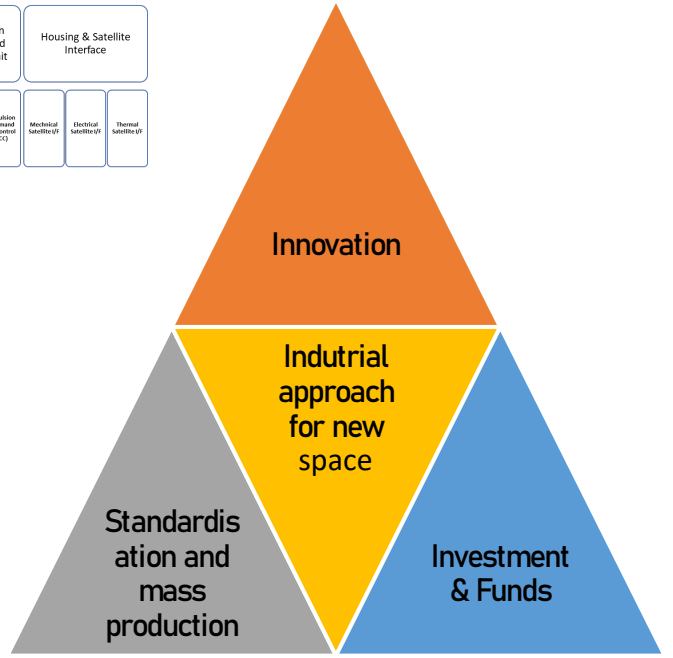
- ✓ To be competitive and insure quality
  - Mechanical parts are manufactured in our workshop
  - Electronic are manufactured and controlled on fully automatized lines following IPC and class 3 standard
  - Integration are done in our clean rooms with a flexible & generic manufacturing products lines (for all products)

Comat manufacturing lines & supply chain are designed to be able to deliver hundreds to thousands products a year

Plasma Jet Pack

Market & vision



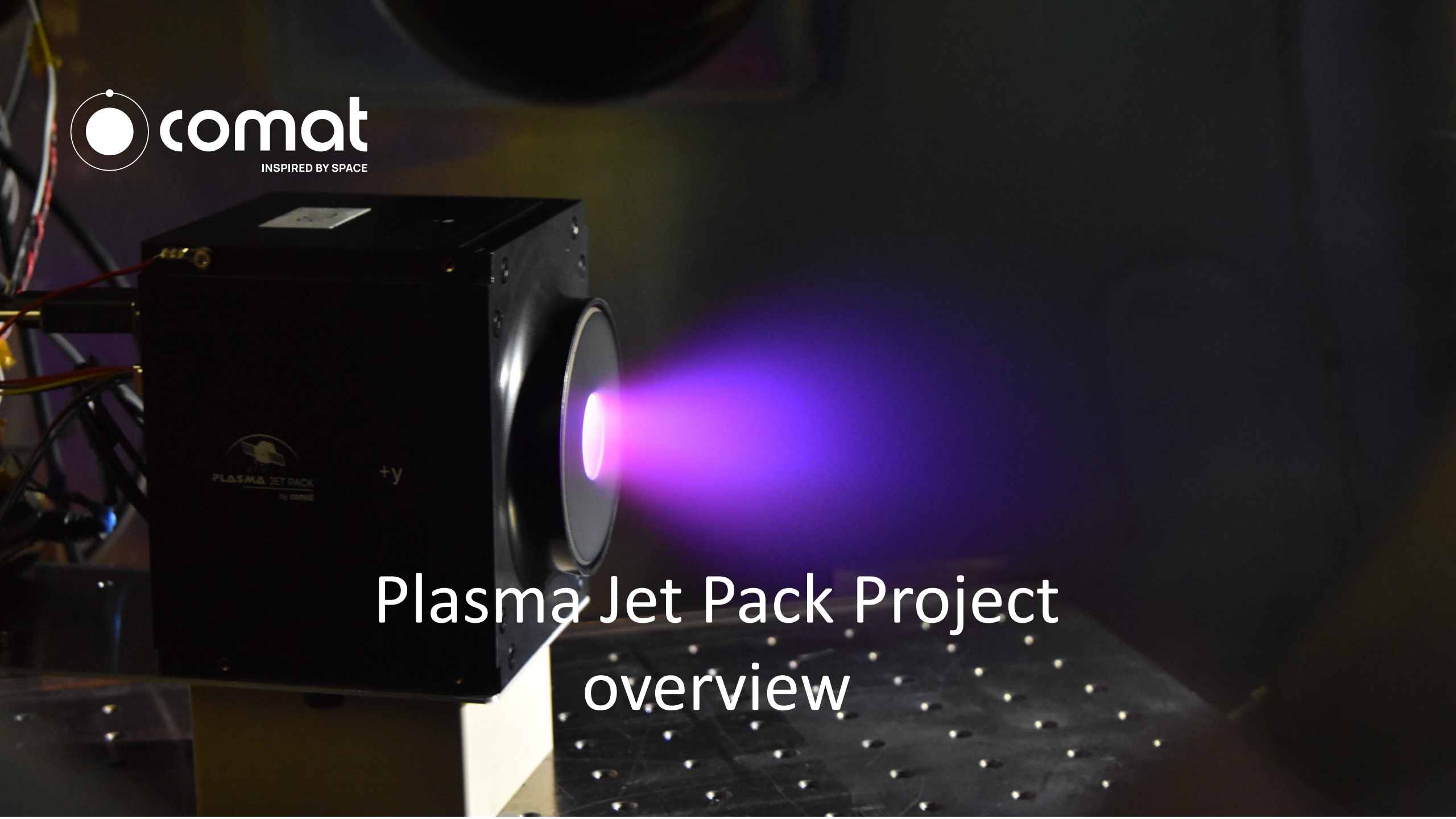


✓ Technology building blocks and components

- 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
- Intern methodology to develop space equipment compatible with mass production using industrial COTS (in less than 1 year)



Plasma Jet Pack Project overview

Plasma Jet Pack

Introduction- Objectives & teams

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 870444

Plasma Jet Pack

Introduction- Objectives

✓ **PJP global objective :** The Plasma Jet Pack project will develop and validate up to qualification level all the building blocks of the technology. The PJP0-30 will be qualified and an IOD/IOV will be performed within 3 years.

› Objective 1: Consolidation of the propulsion specific performance characteristics (specific impulse, thrust-to-power ratio, impulse bit, efficiency…) of vacuum arc thruster physics. 

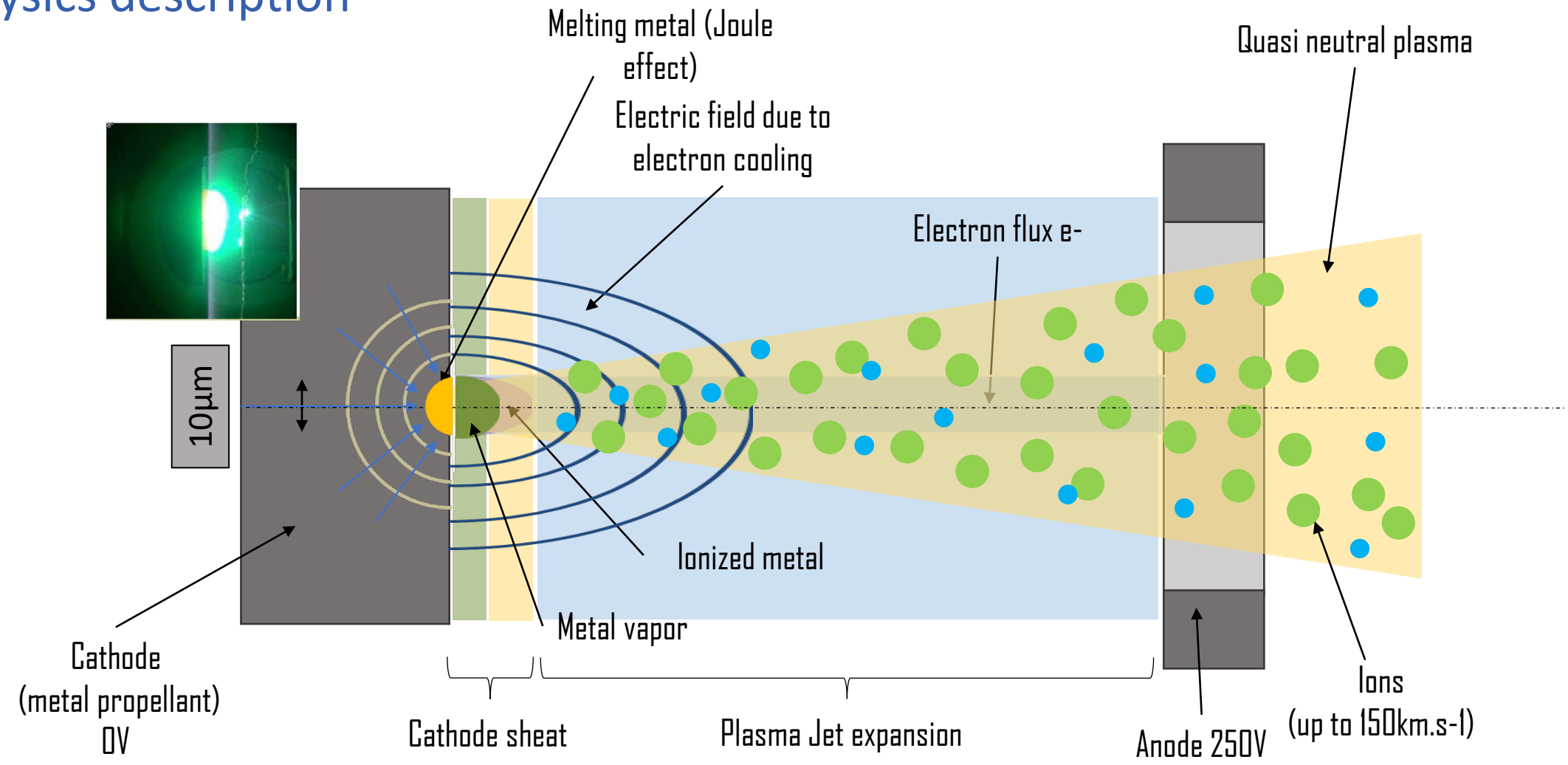
› Objective 2: Improve Plasma Jet Pack's thrust duration. 

› Objective 3: Development and test of a fully representative propulsion module: the PJP 0-30. 

› Objective 4: Analysis of market needs and mission & satellite integration. 

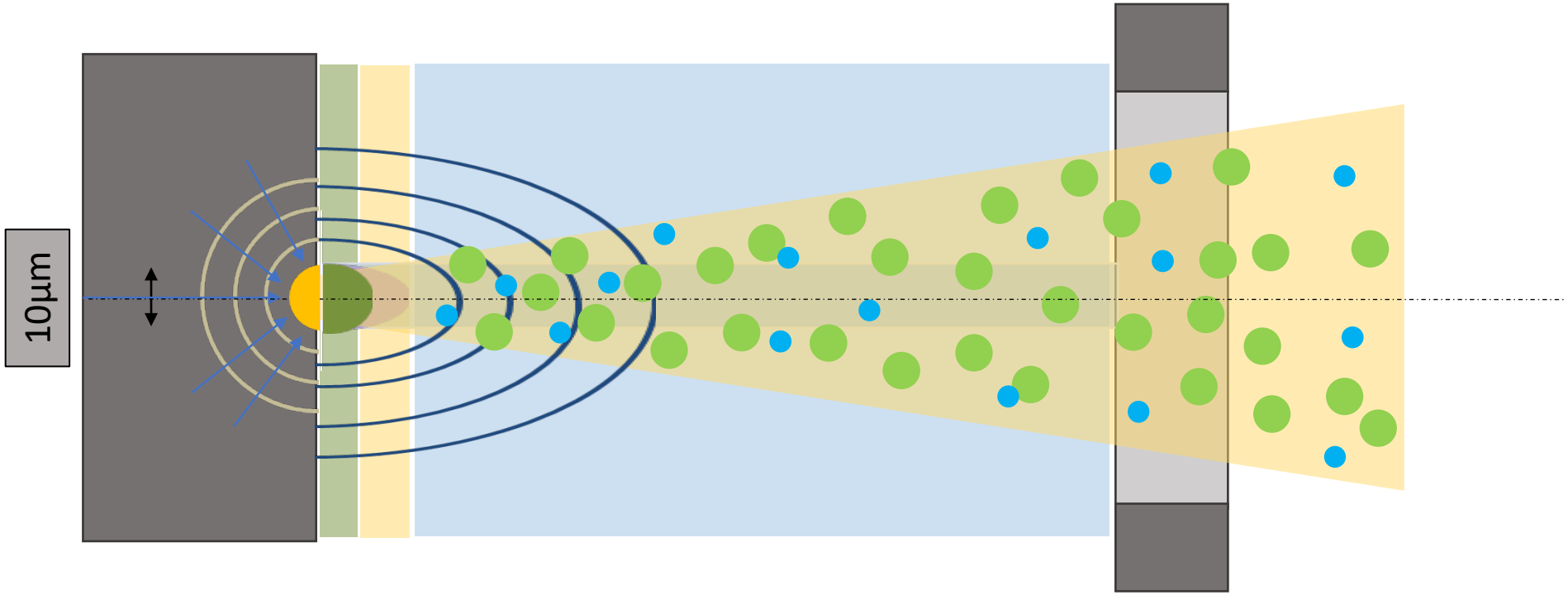
Plasma Jet Pack

Physics description



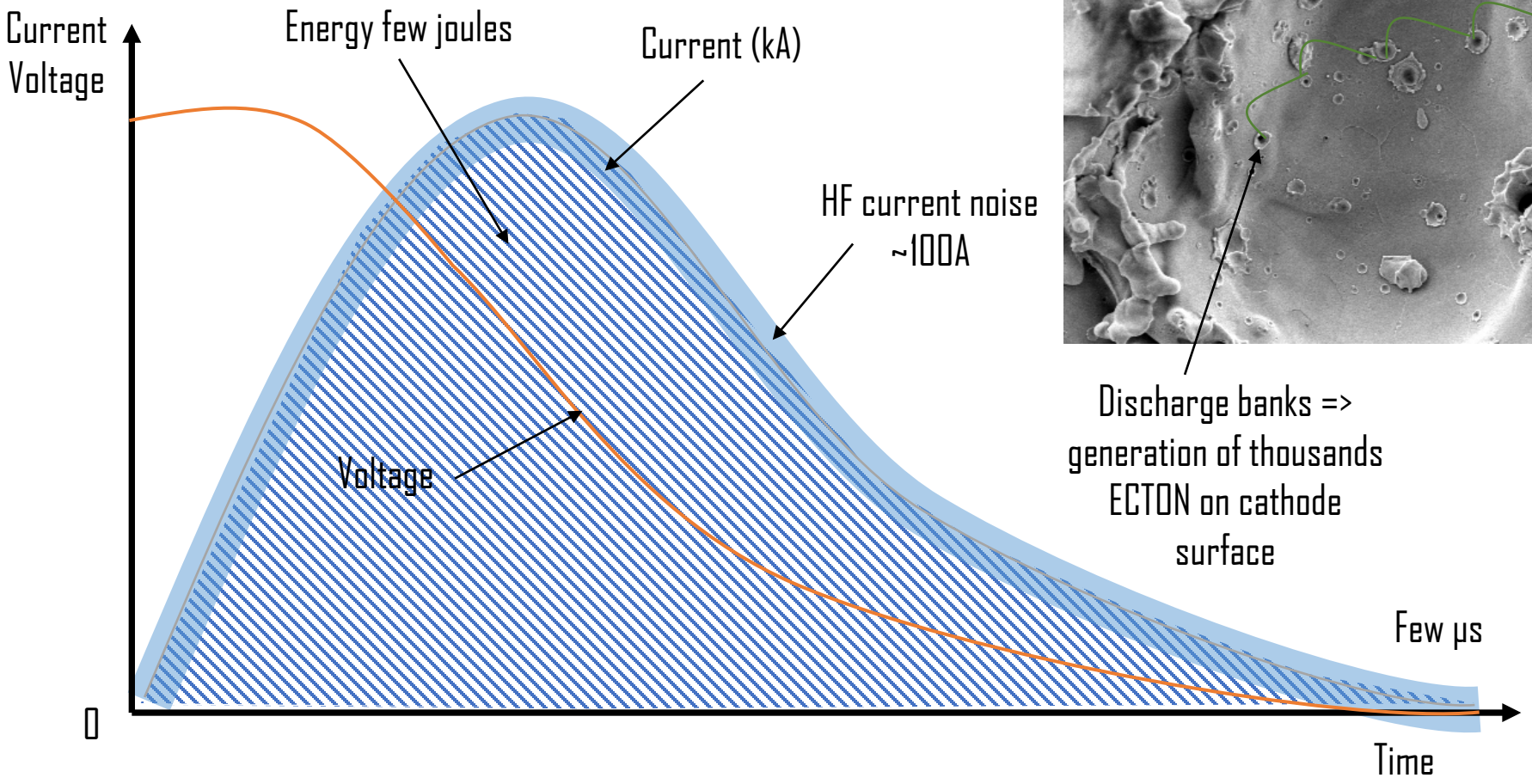
Plasma Jet Pack

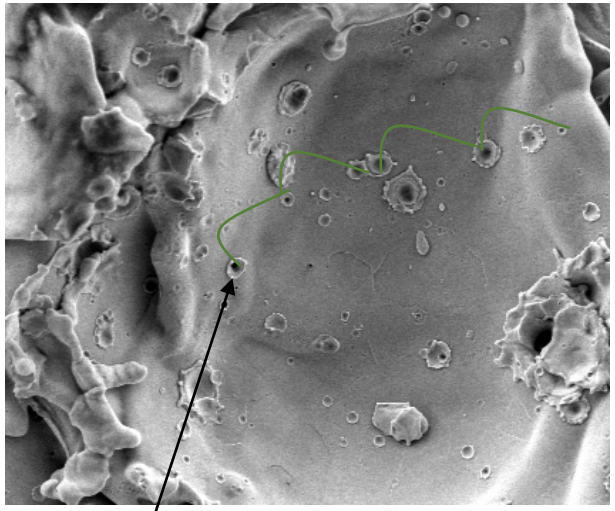
Physics description



Plasma Jet Pack

Physics description





Discharge banks => generation of thousands ECTON on cathode surface

Plasma Jet Pack

Development plan (engineering)

- ✓ Milestones and planning

Arc Discharge Chamber (ADC)

H2020 IOD/IOV lesson learnt on Experiment

Target modifications

Architecture modifications

- Arc Discharge Chamber (ADC)
  - Vacuum Arc Chamber (VAC)
  - High Voltage Triggering Sytem (HVTS)
  - Magnetic Nozzle (MN)
  - Passive Cathode Feed Mechanism (PCFM)

PJP	2020		2021			
	S1	S2	S1	S2	S1	S2
	KO	SRR	PDR		CDR	QR
	1 ADC (4kNs) characterization		4 ADC (100N.s and then 1000N.s)			
	Induced magnetic field exploration		Permanent magnet			
	Designed Manufacturing	Characterization	Designed Manufacturing	Characteriz ation	Iteration	
	Fixed cathode		Mobile cathode			
	Designed Manufacturing	Character ization	Designed Manufacturing	Characterisation	Iteration	
						Qualification

Will be detailed later

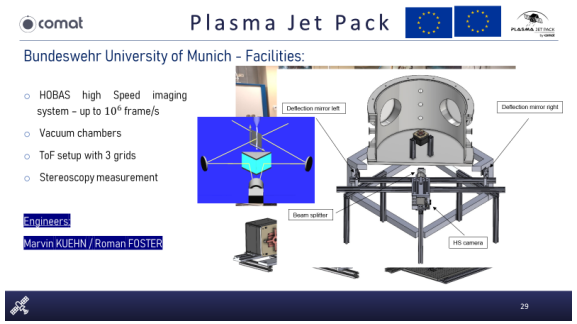
Phase A | Phase B | Phase C | Phase D

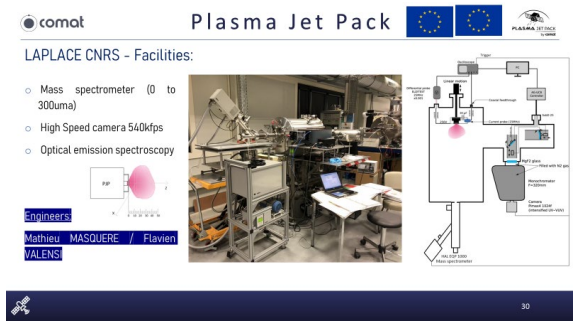
Plasma Jet Pack

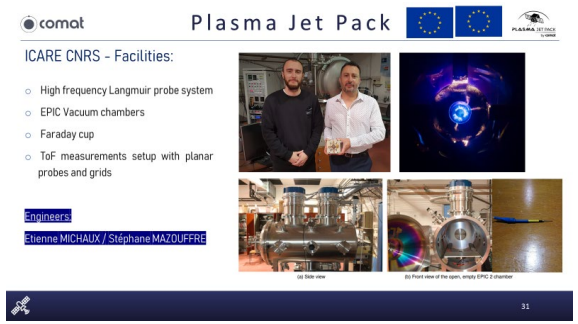
Objective 1 – consolidation of specific performances

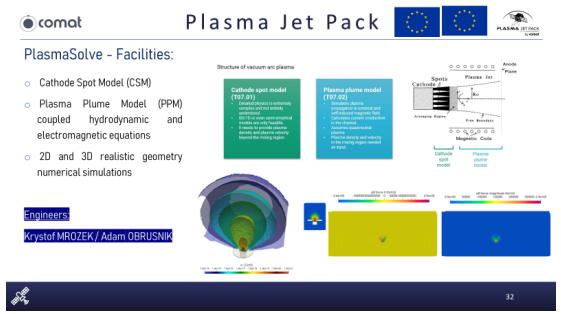
- ✓ Objective 1: Consolidation of the propulsion specific performance characteristics (specific impulse, thrust-to-power ratio, impulse bit, efficiency…) of vacuum arc thruster physics.

- › Presented in details last year by Antoine !

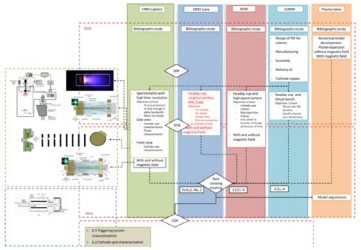


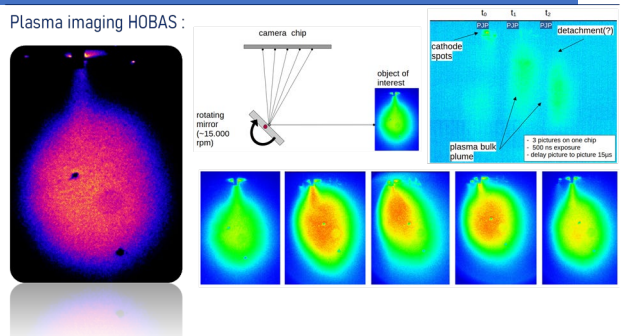






Numerous data has been generated to have a better understanding of the physics, these data answer to all our scientific issues of the work plan



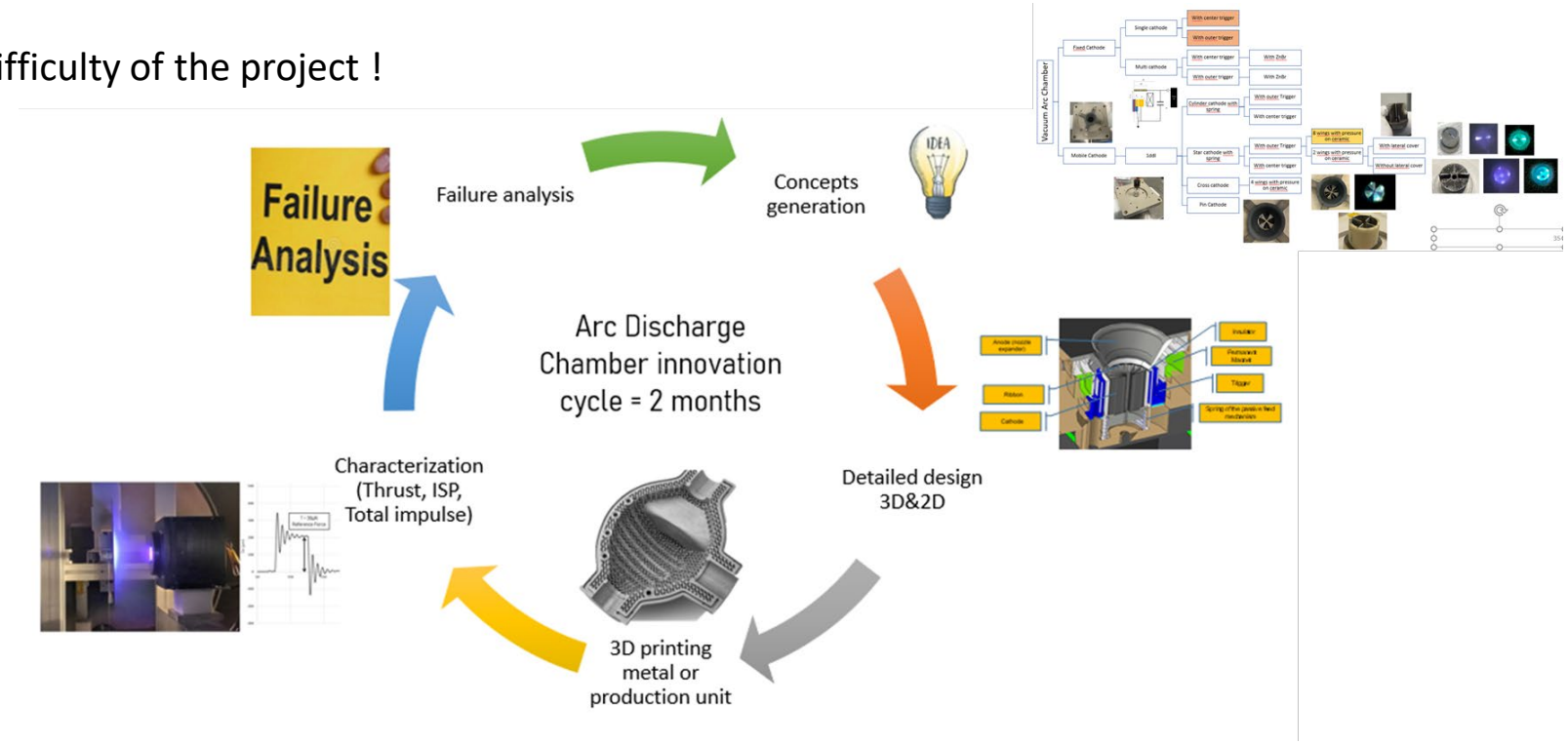


Plasma Jet Pack

Objective 2 – total impulse

✓ Objective 2: Improve Plasma Jet Pack's thrust duration

› Now the main difficulty of the project !



We developed and tested more than 12 configurations

Plasma Jet Pack

Objective 2 – total impulse

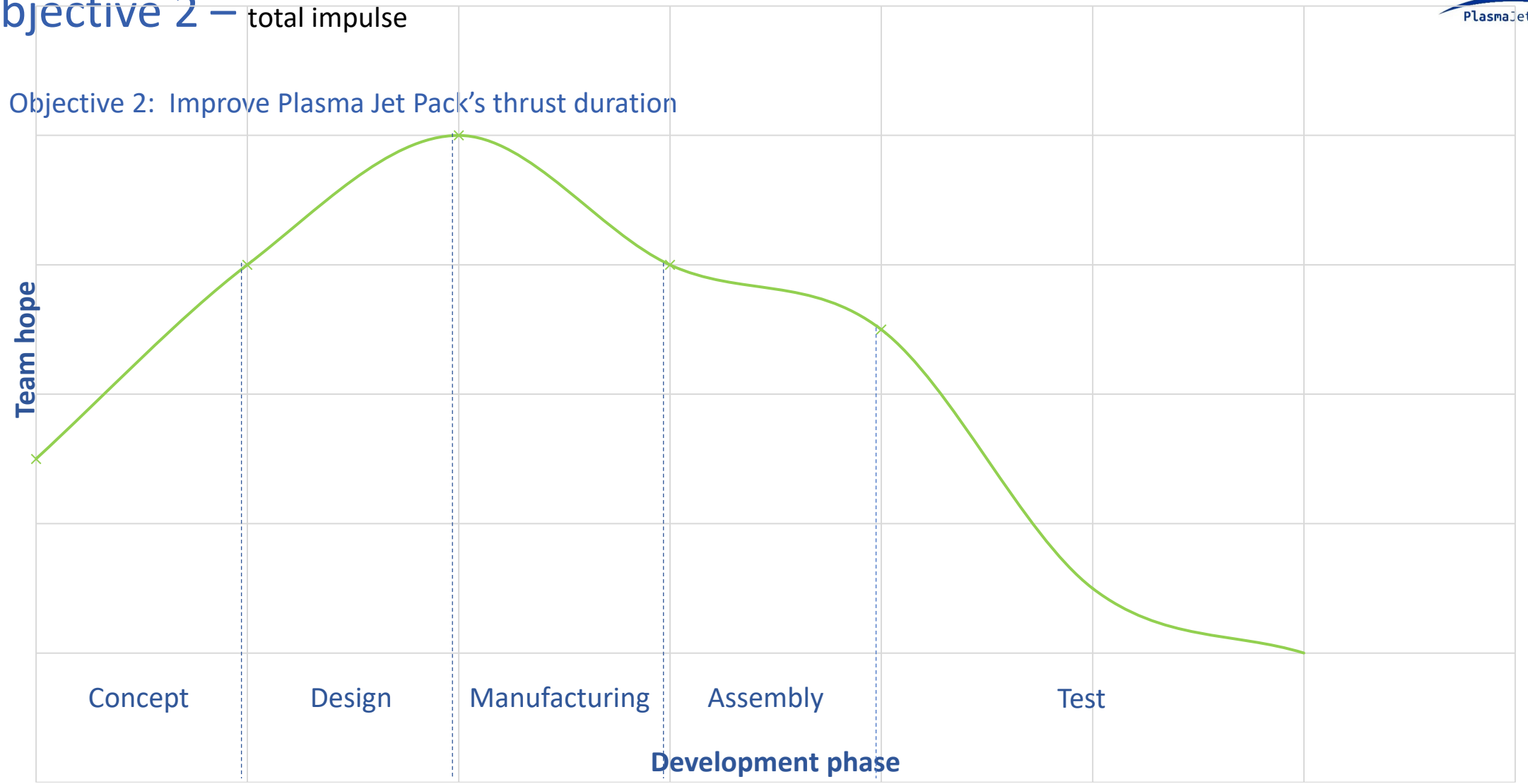
✓ Objective 2: Improve Plasma Jet Pack's thrust duration

We defined a work plan for the next two years to be focus on erosion technology with dedicated parametric electronic hardware

Plasma Jet Pack

Objective 2 – total impulse

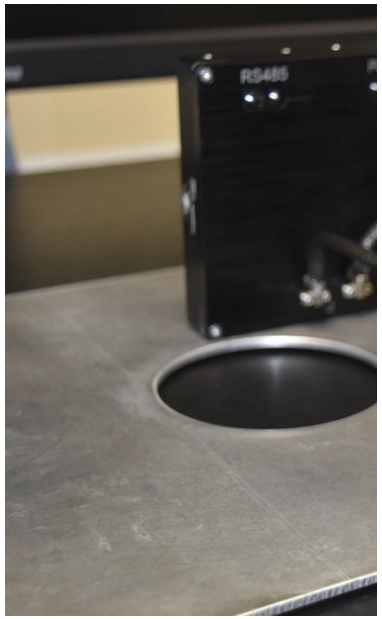
- ✓ Objective 2: Improve Plasma Jet Pack's thrust duration

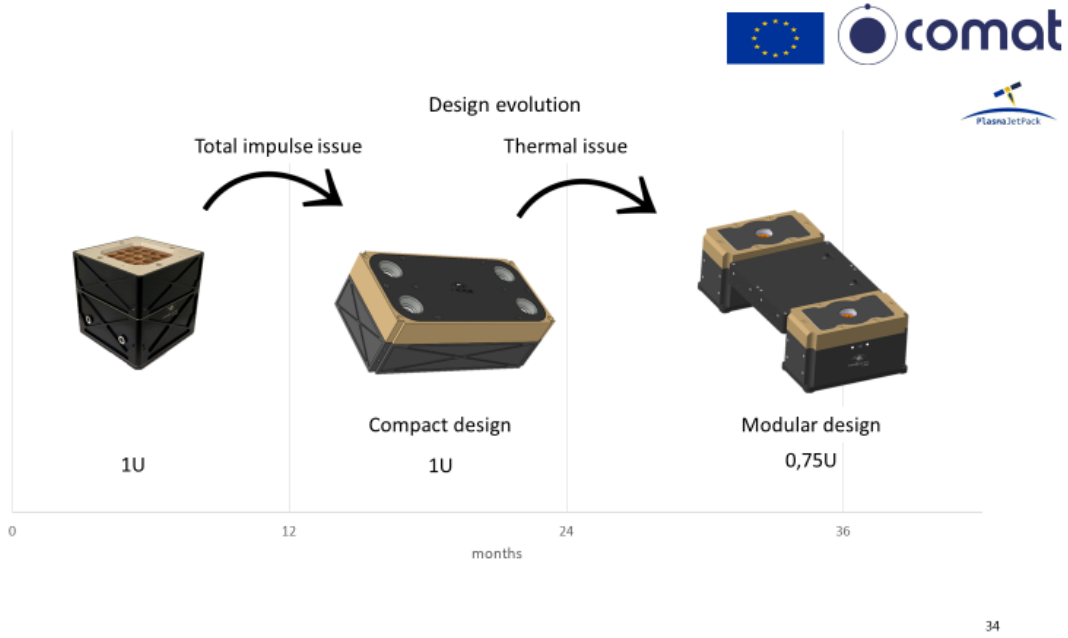


Plasma Jet Pack

Objective 3 – Development and test of a fully representative propulsion module: the PJP 0-30.

✓ Objective 3: Development, test and qualification of a fully representative propulsion module: the PJP 0-30.



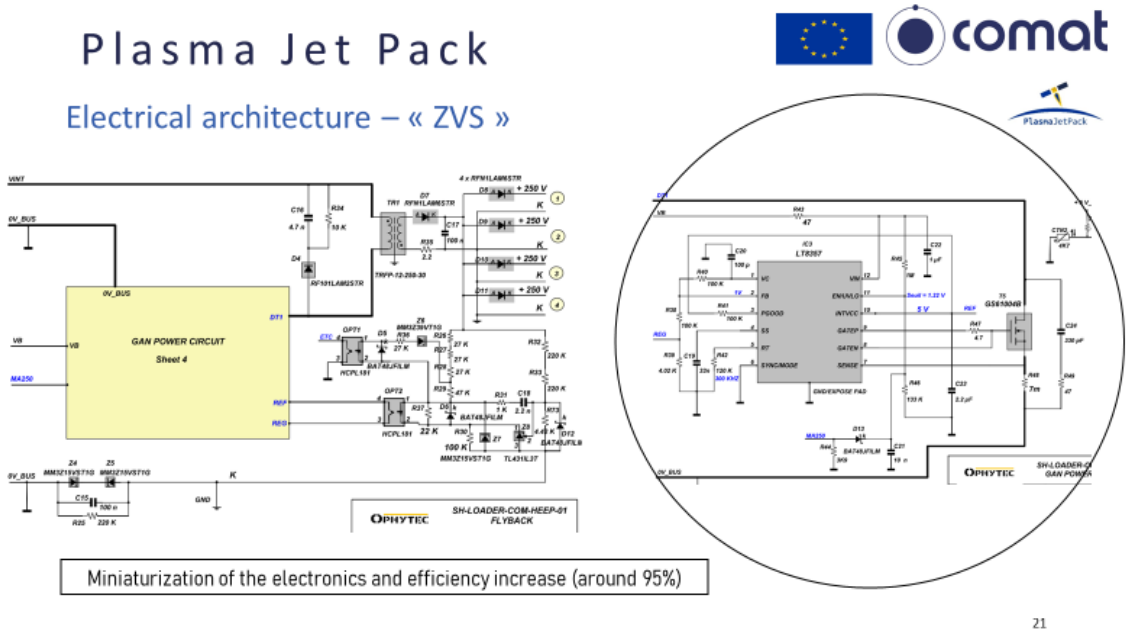


We successfully developed and characterised and qualified 2 propulsion modules during this project

Plasma Jet Pack

Objective 3 – Development and test of a fully representative propulsion module: the PJP 0-30.

✓ Objective 3: Development, test and qualification of a fully representative propulsion module: the PJP 0-30.

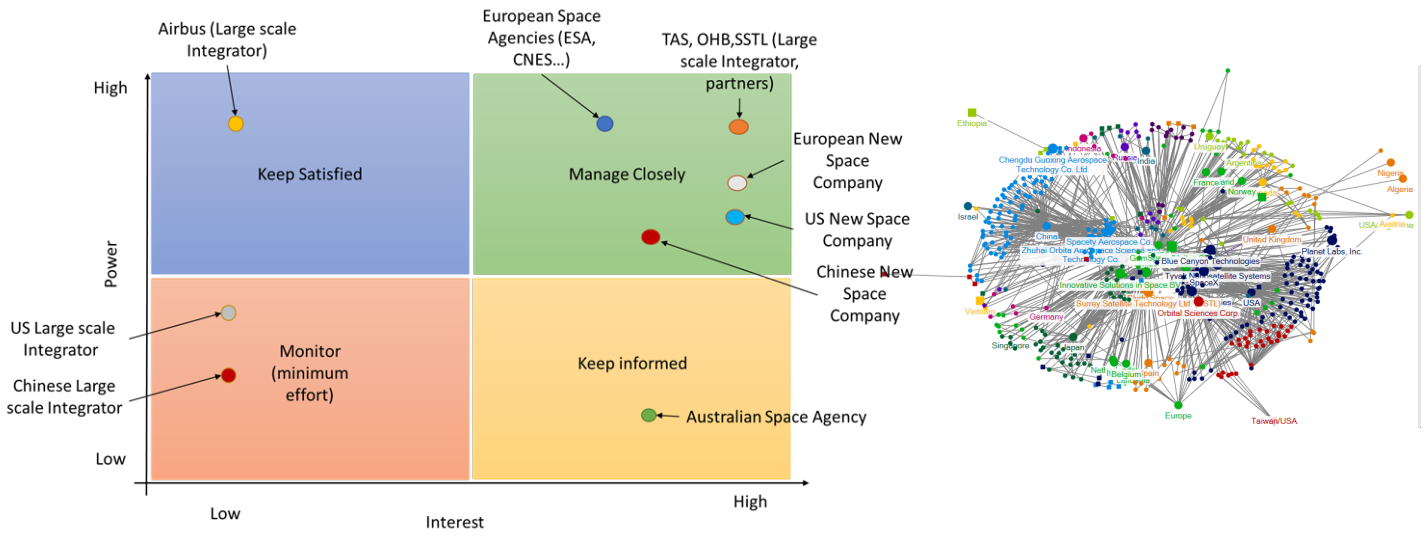


We successfully developed and characterised and qualified building blocks PPSCU

Plasma Jet Pack

✓Objective 4 –Analysis of market needs and mission & satellite integration.

✓ Objective 4: Analysis of market needs and mission & satellite integration.



We have defined the target market for the available technology performances

Plasma Jet Pack

✓ Objective 4 – Analysis of market needs and mission & satellite integration.

✓ Objective 4: Analysis of market needs and mission & satellite integration.

› Products from PJP technology

✓ Technical :

› Metal propellant

› On-demand thrust

› Vectorized thrust

› Thrust adjustable as function of frequency

› Geometry can be adapted as function of requireme

› plug & play product

✓ Commercial :

› Itar free technology

Safe

=> high density propellant

Small volume

=> high density propellant

Low cost

=> Basic architecture

Environment friendly

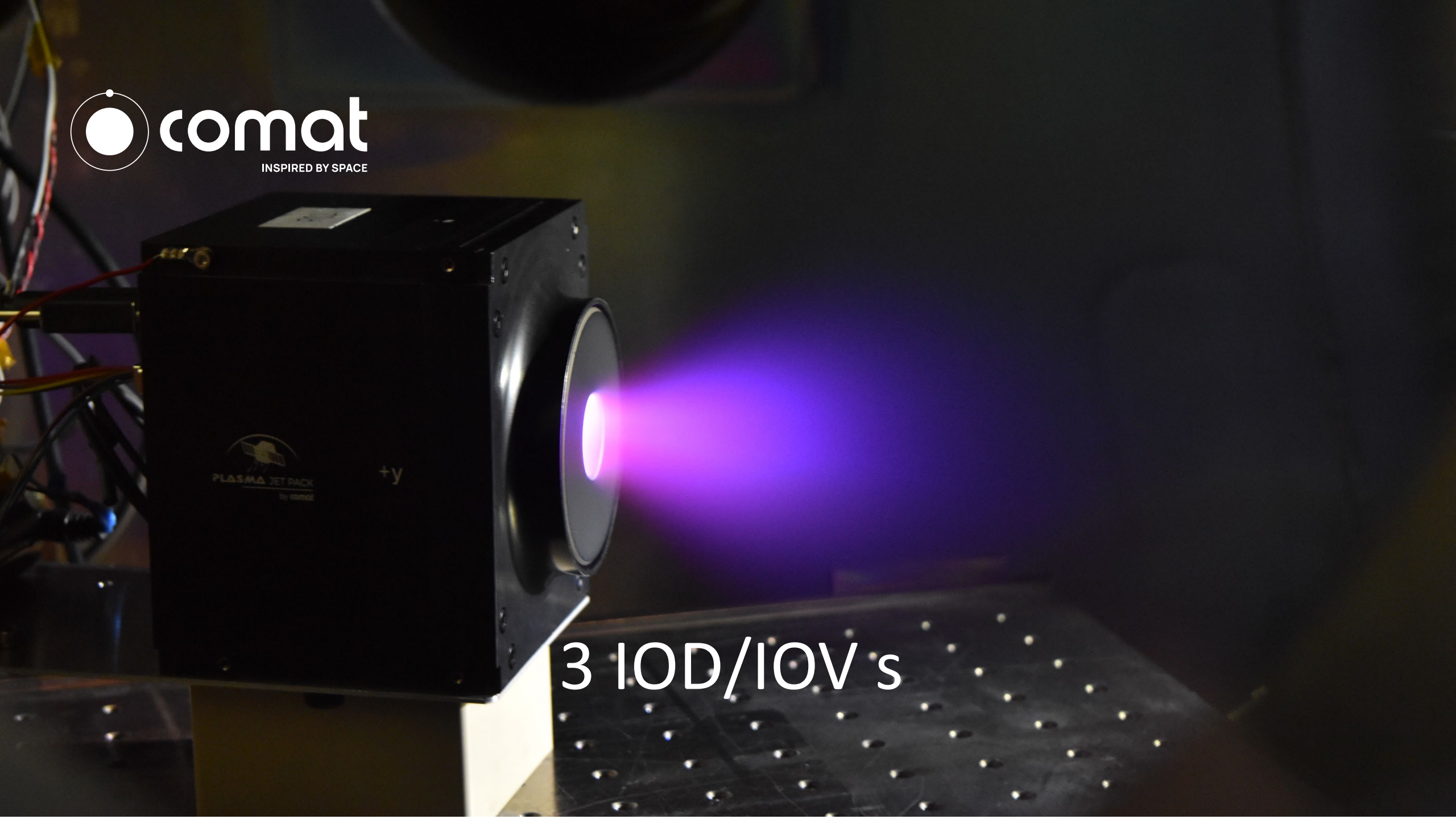
=> inert solid metal propellant and ROHS process

ITAR free

=> use of COTS

Adapted to low power

=> pulsed plasma thruster



3 IOD/IOV s

Plasma Jet Pack

IOD/IOV mission Harbin Institute of Technology

- The main purpose is to **perform a comparison between the on-ground and the in-flight measurements** of the PJP parameters.
- Deliver on September 2019
- In flight since October 2022

- The mission will be done on a **100kg Platform designed by HIT @900km.**

Plasma Jet Pack

IOD/IOV mission Harbin Institute of Technology

哈爾濱工業大學
HARBIN INSTITUTE OF TECHNOLOGY

Research Centre of Satellite Technology,
Harbin Institute of Technology, No.92, Xidazhi Street, Harbin, Heilongjiang,
China 150001

COMAT
To the attention of Ludovic DAUDOIS
6 Chemin de Vignalis
31130 Flourens
France

April 4th, 2023

Dear M. Daudois,

We are glad to inform you that the Kuaizhou-1A solid carrier rocket successfully launched from the Jiuquan Satellite Launch Center, at 10:24 am on September 6th, 2022. The "Micro Space" low-orbit satellite navigation system S3/S4 test satellite was put into its preset orbit. The launch mission was a complete success.

很荣幸通知大家，2022 年 9 月 6 日上午 10 时 24 分，快舟一号固体运载火箭在酒泉卫星发射中心成功发射。"微空间"低轨卫星导航系统 S3/S4 试验卫星成功送入指定轨道。发射任务圆满成功。

We certify that Comat's PJP30 has completed its mission onboard S3/S4 test satellite successfully.

我们证明 Comat 公司的 PJP30 已成功地在 S3/S4 测试卫星上完成任务。

On behalf of the whole team working on this specific project, we would like to address our warm congratulations to Comat team for this great achievement, marking this flight the first milestone of many more to come in our fruitful partnership.

我谨代表致力于这一具体项目的整个团队，Comat 团队的这一伟大成就表示热烈的祝贺，这标志着这次飞行是我们富有成效的合作关系中更多合作的第一个里程碑。

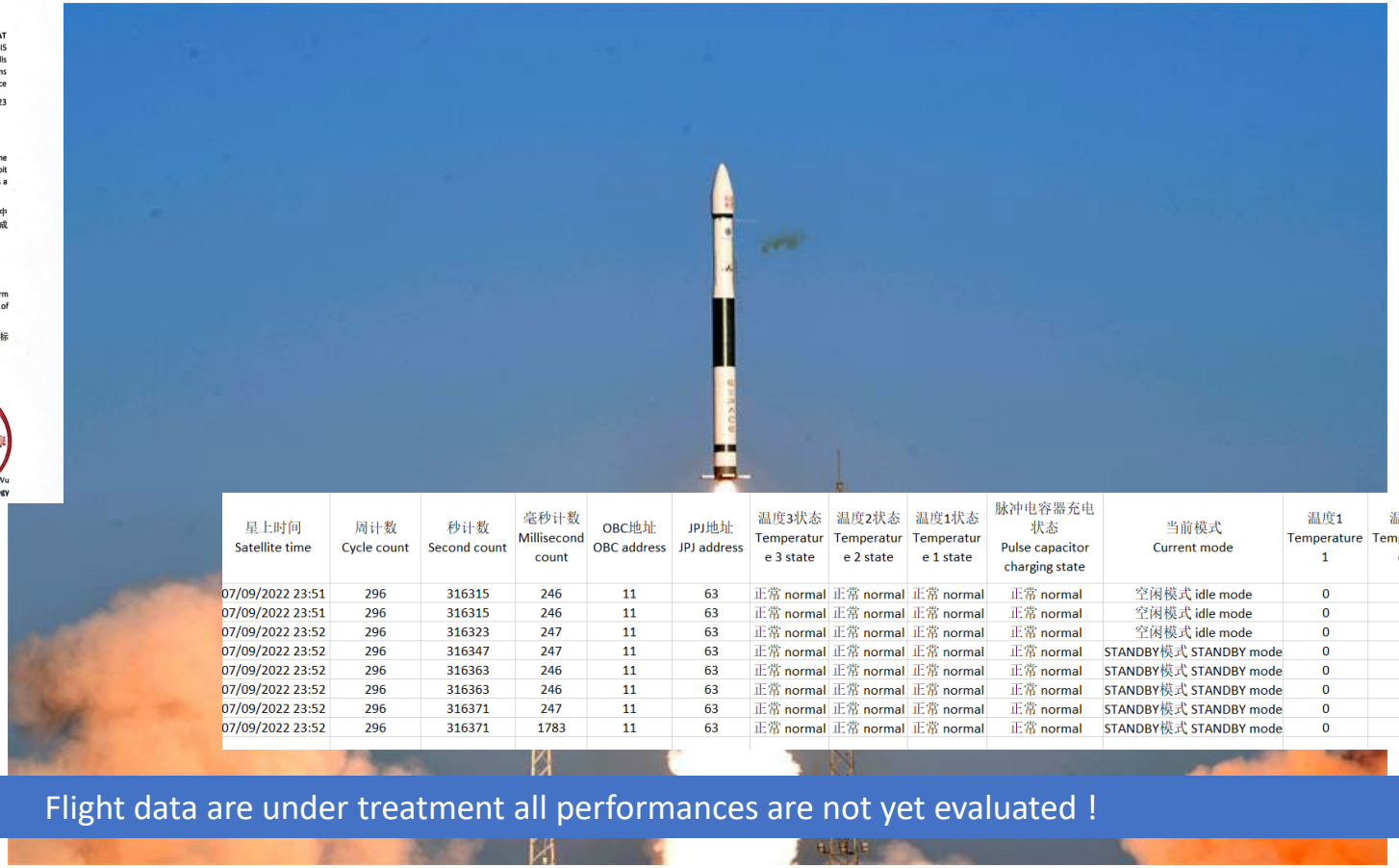
If you have any further questions, please feel free to contact us.

如果有任何问题请随时与我们联系。

Sincerely yours,

此致敬礼

M. Kai Wu
Associate professor at Harbin Institute of Technology



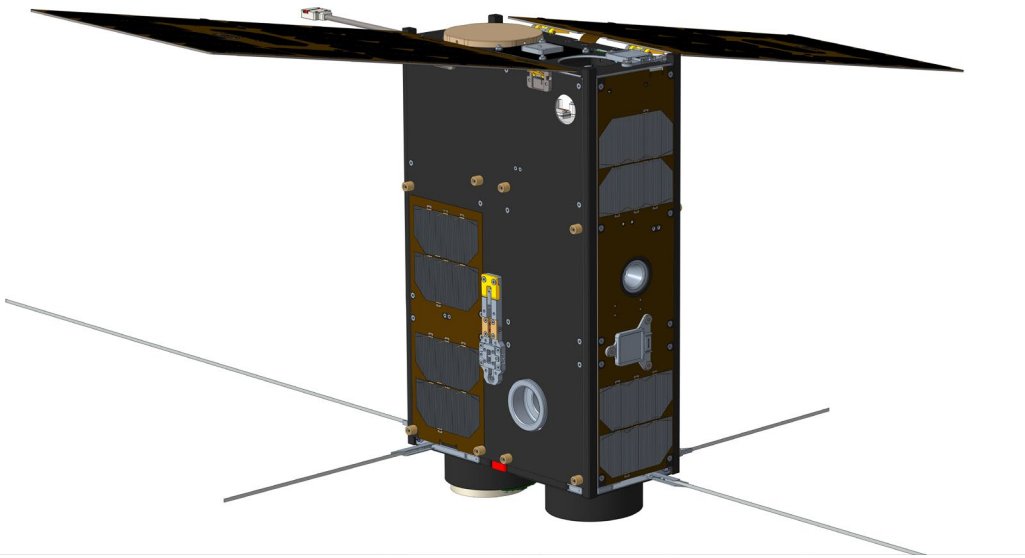
星上时间 Satellite time	周计数 Cycle count	秒计数 Second count	毫秒计数 Millisecond count	OBC地址 OBC address	JPJ地址 JPJ address	温度3状态 Temperature 3 state	温度2状态 Temperature 2 state	温度1状态 Temperature 1 state	脉冲电容器充电状态 Pulse capacitor charging state	当前模式 Current mode	温度1 Temperature 1	温度2 Temperature 2	温度3 Temperature 3	脉冲电压 impulse voltage	剩余脉冲数(LSB, MSB) Residual pulse number(LSB,MSB)
07/09/2022 23:51	296	316315	246	11	63	正常 normal	正常 normal	正常 normal	正常 normal	空闲模式 idle mode	0	0	220	221	44252
07/09/2022 23:51	296	316315	246	11	63	正常 normal	正常 normal	正常 normal	正常 normal	空闲模式 idle mode	0	0	220	221	44252
07/09/2022 23:52	296	316323	247	11	63	正常 normal	正常 normal	正常 normal	正常 normal	空闲模式 idle mode	0	0	219	221	44248
07/09/2022 23:52	296	316347	247	11	63	正常 normal	正常 normal	正常 normal	正常 normal	STANDBY模式 STANDBY mode	0	48	219	216	43475
07/09/2022 23:52	296	316363	246	11	63	正常 normal	正常 normal	正常 normal	正常 normal	STANDBY模式 STANDBY mode	0	0	218	206	43474
07/09/2022 23:52	296	316363	246	11	63	正常 normal	正常 normal	正常 normal	正常 normal	STANDBY模式 STANDBY mode	0	0	218	206	43474
07/09/2022 23:52	296	316371	247	11	63	正常 normal	正常 normal	正常 normal	正常 normal	STANDBY模式 STANDBY mode	0	0	219	203	43473
07/09/2022 23:52	296	316371	1783	11	63	正常 normal	正常 normal	正常 normal	正常 normal	STANDBY模式 STANDBY mode	0	0	219	203	43473

Flight data are under treatment all performances are not yet evaluated！

Plasma Jet Pack

IOD/IOV mission H2020

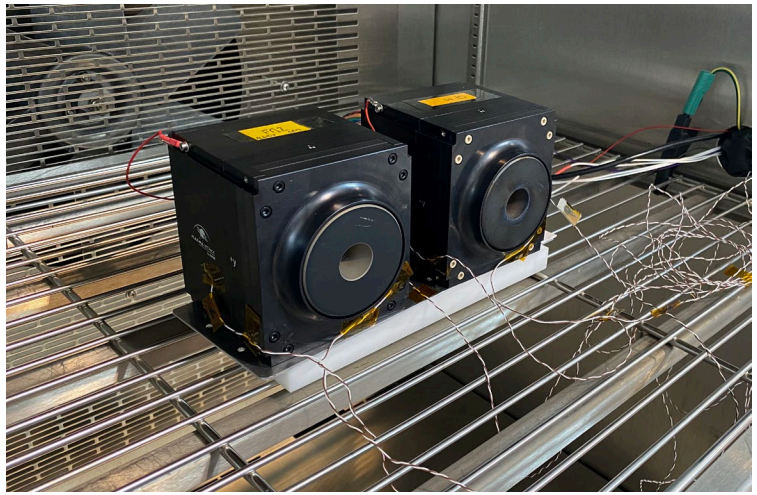
- The main purpose is to **perform a comparison between the on-ground and the in-flight measurements with magnetic nozzle** of the PJP parameters.
- The mission will be done on a **6U Platform designed by ISIS Space.**
- **In-orbit acceptance / verification**
  - Software validation protocol
- **Main Experiment**
  - Thrust estimation
  - Temperature monitoring
  - Ignition rate
  - Number of pulses executed
- **Launch Q3 2023**



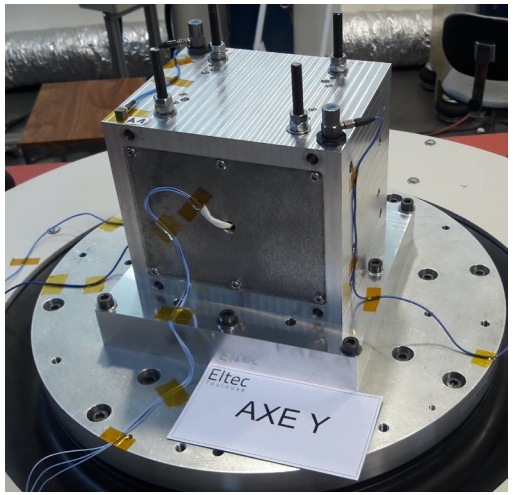
Plasma Jet Pack

IOD/IOV mission H2020

- ✓ Qualification sequence

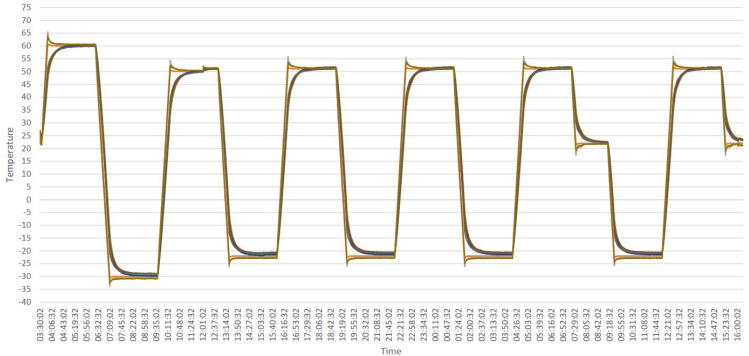


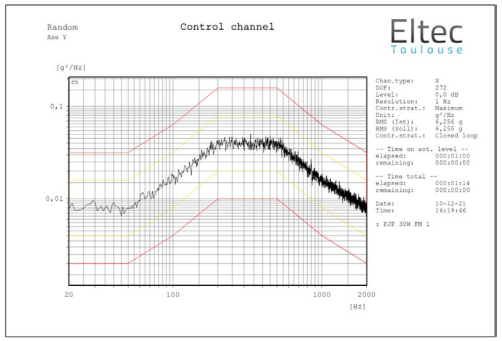
Thermal tests

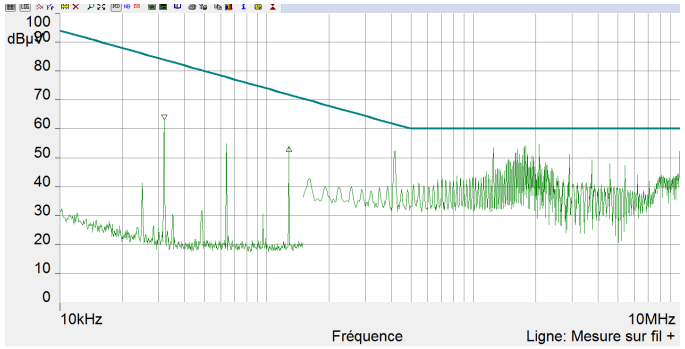


Mechanical tests

EMC tests



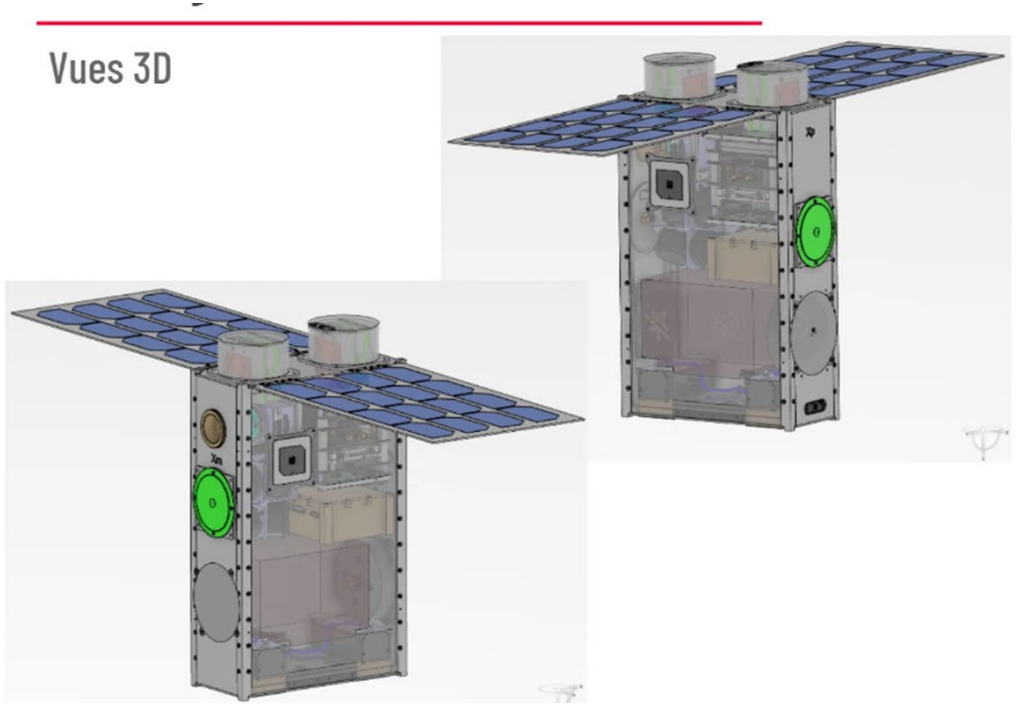


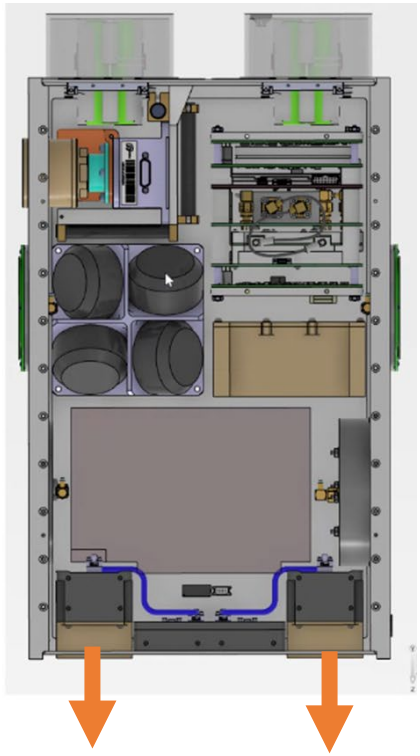


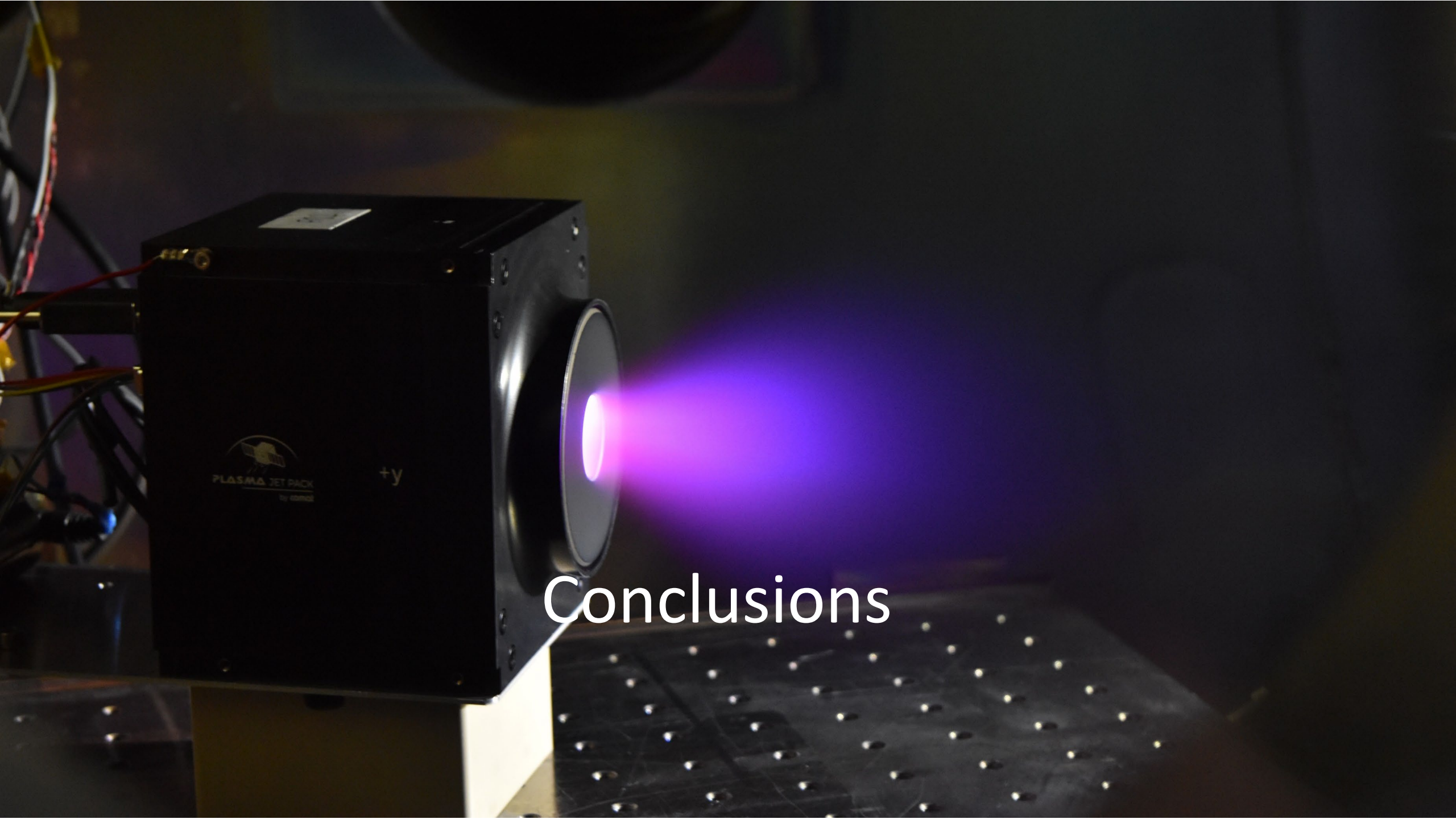
Plasma Jet Pack

IOD/IOV mission CNES

- The main purpose is to prove the capability to perform vectorisation, attitude control and reaction wheel desaturation.
- The mission will be done on a **6U Platform designed by USpace.**
- **In-orbit acceptance / verification**
- **Main Experiment**
  - Thrust estimation
  - Temperature monitoring
  - Ignition rate
  - Number of pulses executed
  - **Attitude control**
  - **Reaction wheel desaturation**
- **Launch mid 2024**







Conclusions

Plasma Jet Pack

Project & Figures

✓ PJP figures :

- Presentation : 20 presentations
- Publications : 10 publications (1 reference about time space expansion of the plasma)
- Thesis : 1 thesis up to 2026
- Manufactured model : more than 10 for labs and in orbit demonstration and qualification
  - 4 for labotories experiment
  - 3 Qualification IOD/IOV H2020 ISIS
  - 3 IOD/IOV for Synchrocube French government satellite

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Conclusions

✓ Market target

- We change our market target for the first version of the product : for 6U station keeping (2*60Ns)
- The first fully qualified product will be available by the mid of 2023

✓ Architecture

- This architecture allows to qualify independently the two main subassemblies : PSCU, and nozzle
- More evolution are possible with different technology (PPT,P-MPD) thanks to this architecture

✓ H2020 collaboration

- The collaboration with European partners is fruitful leading to publications and knowledge improvement directly usable for COMAT (Magnetic topology etc…)

Plasma Jet Pack

Next steps

✓ Focus on technological development

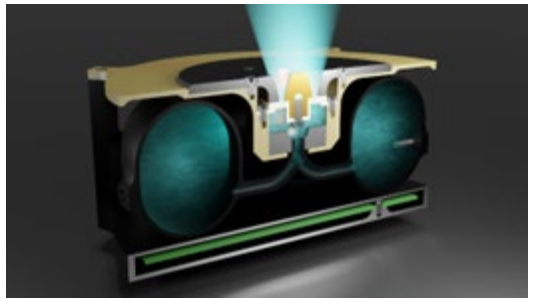
› We propose to be focused on total impulse and technological fundamentals for the next two years. With a fully open electronic hardware to explore different energy configuration (voltage and current)

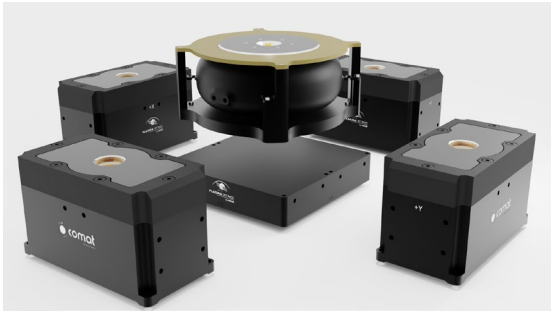
✓ IOV

› A flight model will be delivered for IOV of our first product in 6U satellites : ISIS and USpace

✓ Modular approach

› Open the way to different configurations and technologies of nozzles (PJP and P-MPD)





Research and Innovation In Actions :
SPACE-13-TEC-2019: SRC-In-Space electrical propulsion and station keeping

comat
INSPIRED BY SPACE

11th May 2023

Plasma Jet Pack Overview EPIC 2023