



CLEAN SPACE INDUSTRIAL DAYS
ESTEC- October 24, 2017

Passivation device for Spacecraft Propulsion System the μ Perforator LXT C5026

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SUMMARY

1. Scope of the Development & Qualification of the μ Perforator
2. Propulsion systems to be passivated with a dedicated device
3. Product key drivers
4. Development & Qualification of the μ Perforator
5. The μ Perforator design
6. The qualification program
7. Extension of the service life of the PC23 initiator
8. NRB : Entegris filter rupture
9. Risk reduction & extension of applications
10. Manufacturing strategy
11. Product configurations
12. Conclusion

1. SCOPE OF THE DEVELOPMENT & QUALIFICATION OF THE μ PERFORATOR

The French Space Act (LOS) & ISO 24113 require the passivation of the energy sources (electrical and propulsion) of the spacecraft at the EOL.

FOR THE PROPULSION PASSIVATION

The CNES guideline states the following objectives:

NTO < 1 bar at 10°C

MMH < 0,15 bar at 10°C

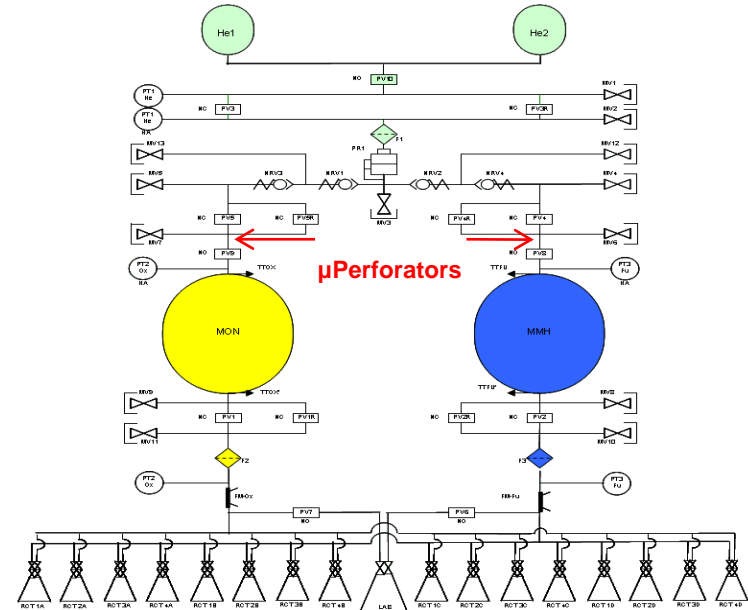
Hydrazine < 0,5 bar at 20°C



Pyrovalves could be used for some missions but the present service life (8 years) does not comply with the time of the actuation of the passivation function.



The μ perforator is an explosive device suitable to drain at EOL the pressuring gases trapped in the tubing and in the tanks.



2. PROPULSION SYSTEMS TO BE PASSIVATED WITH A DEDICATED DEVICE

❖ Monopropellant (N₂H₄) propulsion systems with membrane tanks :

- Examples: Proteus, Myriade, Myriade evolution, SAR-Lupe, Galileo, PRIMA, ELiTeBUS (GlobalStar 2, Iridium Next, O3B), Auxiliary propulsion systems of Spacebus Neo and Eurostar Neo.

❖ HP Pressuring tanks of propulsion systems with pressure regulator:

- Examples: Spacebus 3000 and « all chemical and hybrid propulsion systems» such as Eurostar Neo & Spacebus Neo.

3. PRODUCT KEY DRIVERS



1- Life Duration >28 years



2- Price : Low Cost device



3- Integrated particle filters

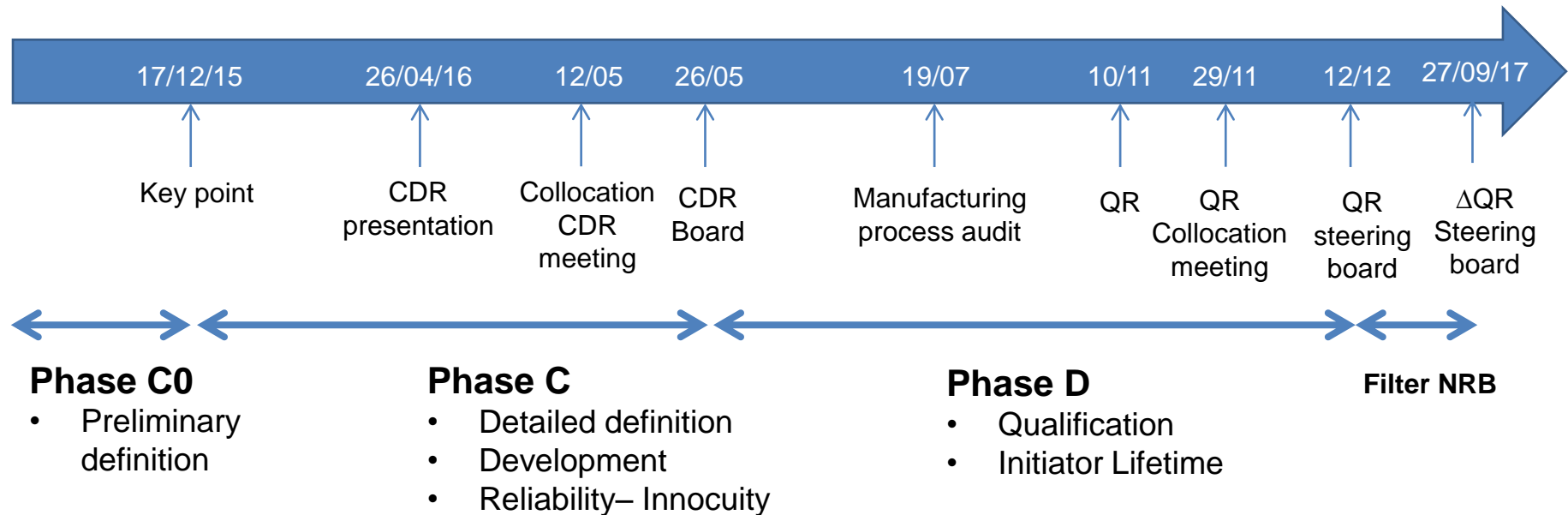


4- Modularity : Common design for HP and LP

4. DEVELOPMENT & QUALIFICATION OF THE μ PERFORATOR

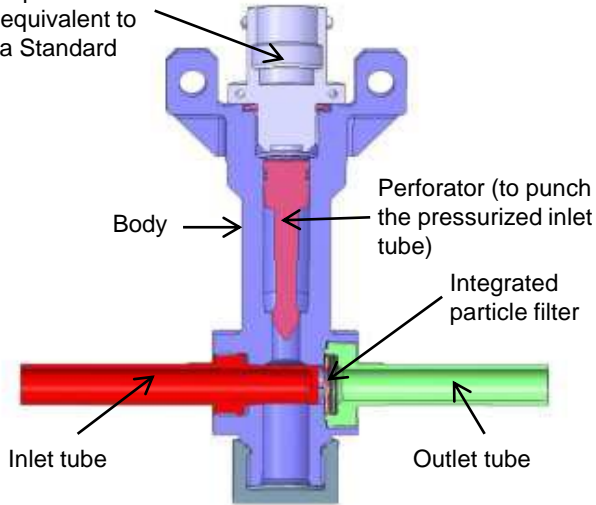
CNES Contract N°150286-00 dated July 9, 2015

○ Milestones

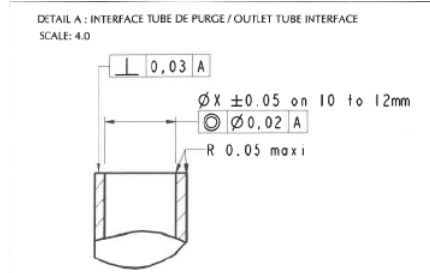
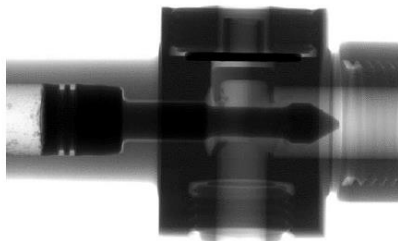


5 THE μ PERFORATOR DESIGN

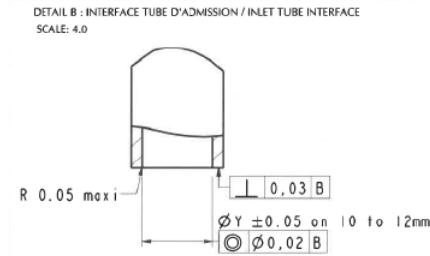
Electro explosive initiator equivalent to the Nasa Standard Initiator



Tubes are welded on the satellite propulsion system



VERSION	PRODUCT NUMBER	X VALUE
High pressure	C5026C0B	4.95
Low pressure	C5026D0A	5.55

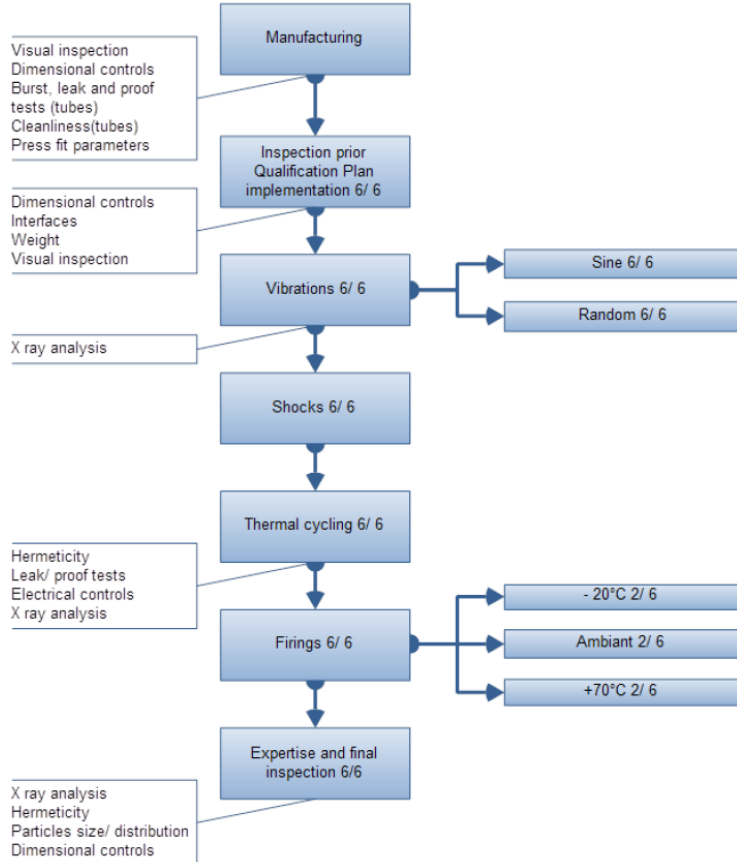


VERSION	PRODUCT NUMBER	Y VALUE
High pressure	C5026C0B	4.95
Low pressure	C5026D0A	5.55

μ Perforator family

P/N	Type	Filter	MEOP	Welding interface	Proof	Burst
C5026C0B	HP	100 μ m	200 bars ²	Internal $\phi 4.95 \pm 0.05$	465 bars	1240 bars
C5026D0A	LP	100 μ m	24 bars	Internal $\phi 5.55 \pm 0.05$	36 bars	96 bars
C5026E0A ¹	HP	without	310 bars	Internal $\phi 4.95 \pm 0.05$	465 bars	1240 bars
C5026F0A ¹	LP	without	24 bars	Internal $\phi 5.55 \pm 0.05$	36 bars	96 bars
C5026G0A ¹	LP	10 μ m	24 bars	Internal $\phi 5.55 \pm 0.05$	36 bars	96 bars

6. THE QUALIFICATION PROGRAM



Random vibrations

32.5 g rms. overall, 3 orthogonal axes - 3min./axis

Frequency	Amplitude
20 - 100 Hz	+15 dB/oct
100 - 400 Hz	1.5 g ² /Hz
400 - 1000 Hz	0,5 g ² /Hz
1000 - 2000 Hz	-6 dB/oct

Sine vibrations

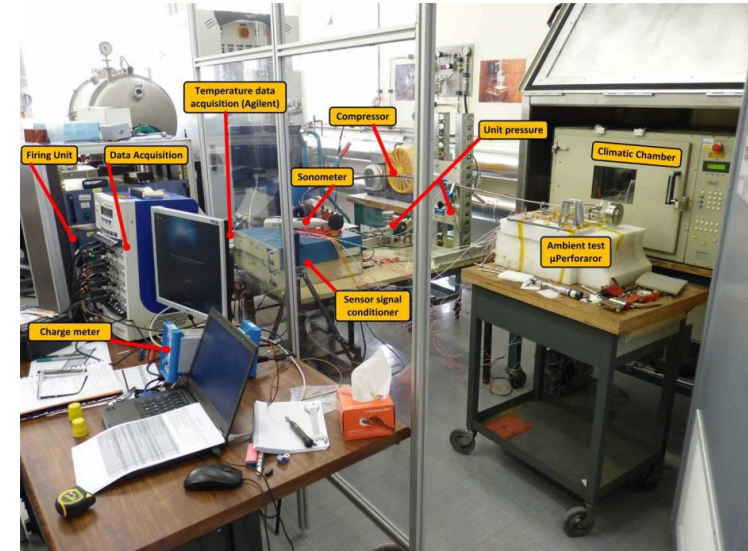
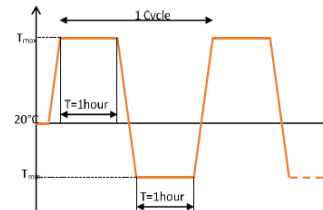
Frequency	Amplitude
5 - 20 Hz	±11 mm
20 - 100 Hz	20 g

Pyro Shocks

Frequencies	Amplitude
100 Hz	20 g
1000 Hz	1500 g
2000 Hz	5000 g
10000 Hz	5000 g

Thermal cycling

8 cycles of -20°C, $\pm 0,4$ °C to +70°C, $\pm 4,0$ °C, 1 hour per cycle were carried out on each QM



CNES PyroLab
Firing test set up

7. EXTENSION OF THE SERVICE LIFE OF THE PC23 INITIATOR

Tests programme applied to «18» PC23 initiators Lot 13-41432 Mfg date : 05/2000

Justification of :

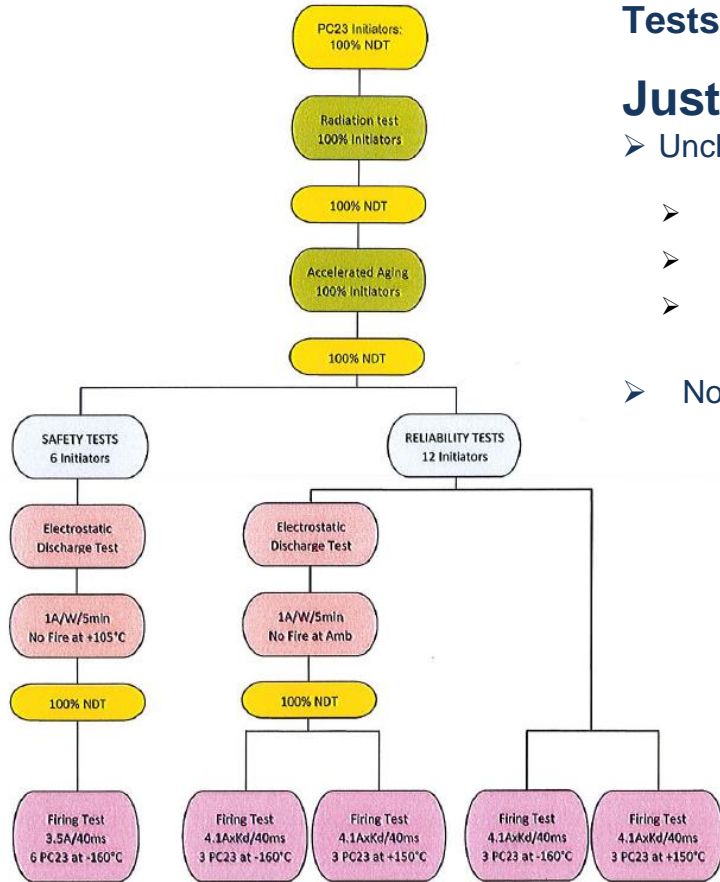
- Unchanged reliability after the test sequence :
 - (0,999 @90%) of the PC23 : severed firing current
 - Worst case tests temperature (idem DLAT of PC23 : +149°C & -162°C)
 - Functioning time - Pressure values in a 10 cc closed bomb shall comply with the PC23 DLAT acceptance values
- No risk of unwanted firing (ESD and 1A/1W/5min No Fire tests at +105°C and ambient)

- *Radiations ⁶⁰Co performed at TRAD in Toulouse TID = 1052krad*
- *Accelerated aging test at CED : +80°C for 83 days by CED – Ea ZPP : 125 kJoules*

CED CONCLUSION

Chemring Energetic Devices has performed Service Life Extension Testing on eighteen (18) Customer furnished PC23 Initiators representing CED Manufacturing Lot Number 13-41432. The test program was performed to extend the service life for 28.5 years from completion of Functional Testing, based on the mission profile specified in CNES Statement of Work DCT/TV/PR-2015.0017365.

The Summary of Tests for this Service Life Extension Program provides objective evidence that all required testing met the acceptance criteria specified in CNES Statement of Work DCT/TV/PR-2015.0017365, and CED Service Life Extension Procedure SLE9391575-6724 Revision A. CED recommends its use for the CNES application.



8. NRB : ENTEGRIS FILTER RUPTURE

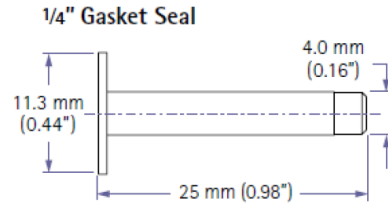
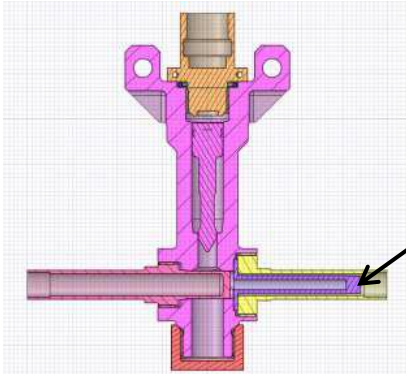
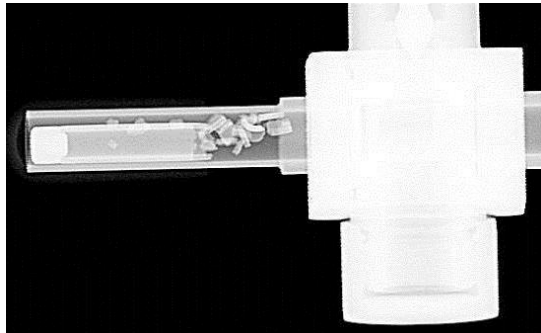


Fig.28 - Filtre Entegris WGPM OGG G2.

Entegris filter selected due to the feedback and qualification on Planck and Microscope missions

- 20 to 30 filters used in HP on Planck and the CGPS Microscope (IDEAS)

Filter rupture during qualification vibrations



Qualification of new filter design and assembly

- Random vibrations
- Pyroshocks
- 3 times Inrush pressure (1,5xMEOP)



Two filters (10 μ m and 100 μ m) qualified compliant to the space debris mitigation requirements particle < 1mm

9. RISK REDUCTION & EXTENSION OF APPLICATIONS

The French Space Act and ISO 24113 require : Break-up probability threshold of the satellite in orbit : Probability of accidental break-up $< 10^{-3}$ until its end of life

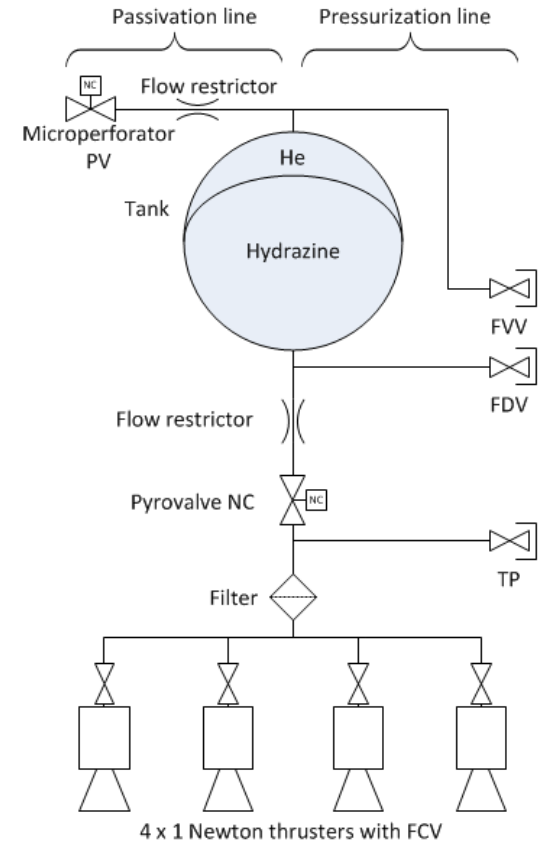
Due to the permeability of the membrane of the tank and the in orbit thermal cycling, liquid hydrazine or a mixture of N_2H_4/He or N_2H_4/N_2 may be located in the inlet tube of the μ Perforator.

CNES has identified that a risk reduction is necessary, when the μ perforator is fired on the liquid N_2H_4 and the N_2H_4/He mixture.

A test program is endorsed by CNES :

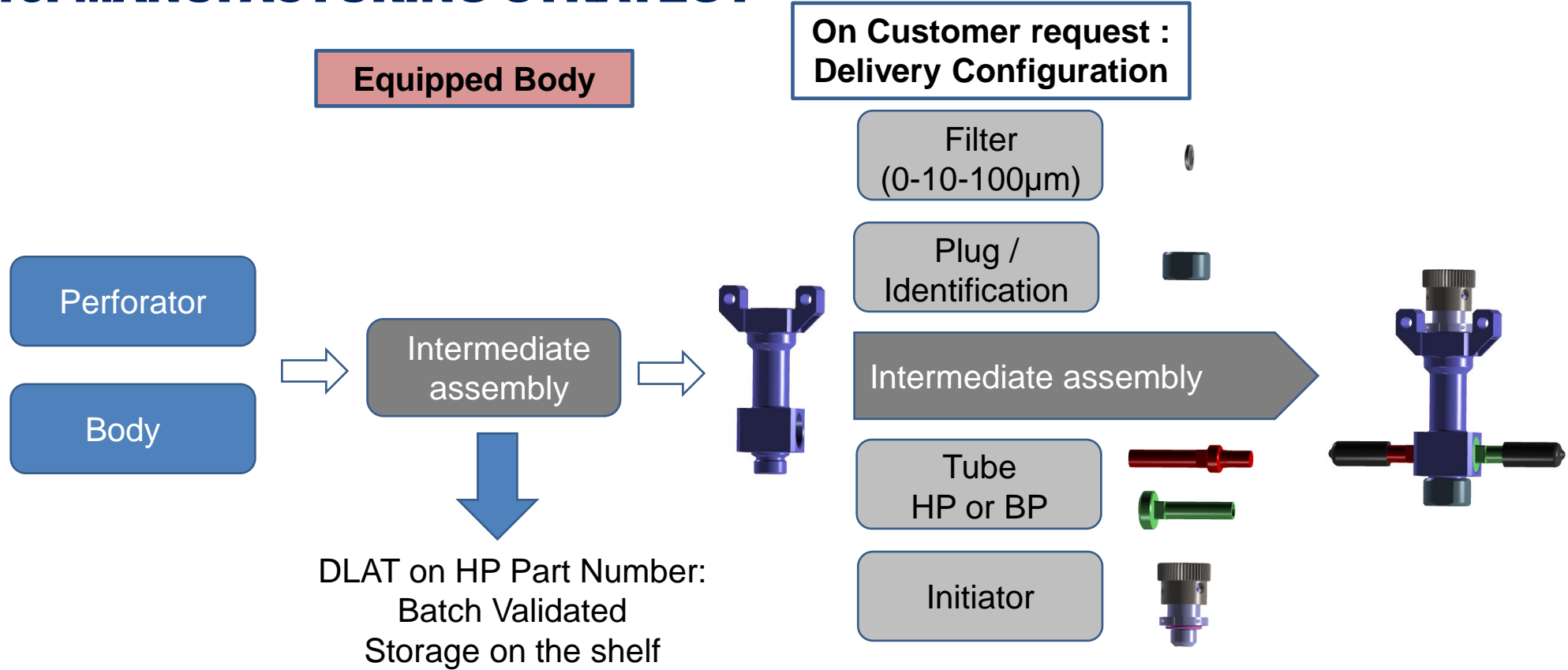
- Step 1 : characterization of the status of the mixture after the worst case thermal environment (condensed liquid, mist or vapor)
- Step 2 : characterization of the reactivity of the mixture – parameters : pressure/temperature-diameter of the flow restrictor – ignition energy
- Step 3 : Tests in worst case conditions with μ Perforators
 - ✓ One on liquid N_2H_4
 - ✓ Two on N_2H_4/He mixture with flow restrictor
 - ✓ Two on N_2H_4/He mixture without flow restrictor

TEST RESULTS EXPECTED : February 2018

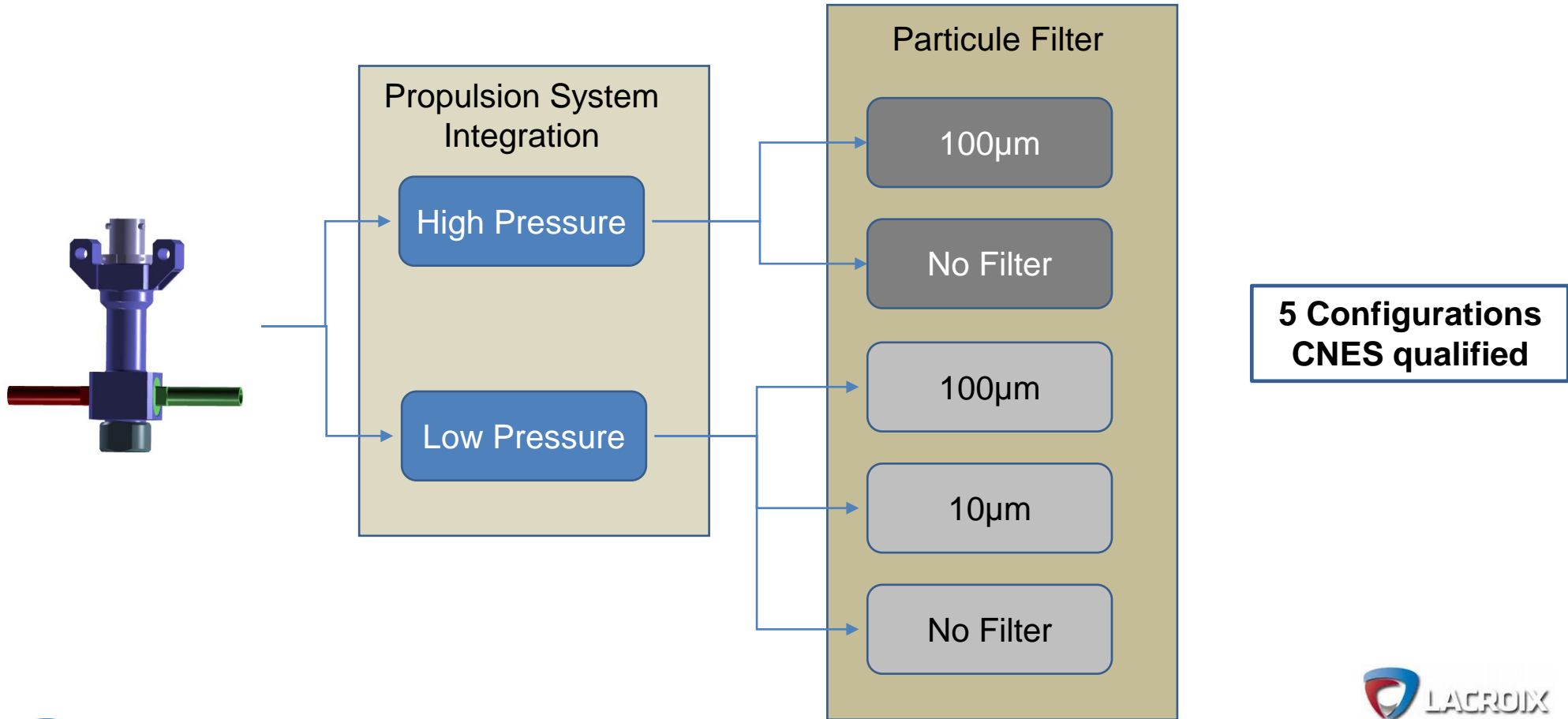


CNES Microcarb propulsion system

10. MANUFACTURING STRATEGY



11. PRODUCT CONFIGURATION



12. CONCLUSION

QUALIFICATION ENDORSED BY THE CNES STEERING BOARD :

- HP and LP μ Perforator without filter : December 2016
- HP μ Perforator with 100 μ m filter and HP μ Perforator with 10 or 100 μ m filter : October 2017

- ❖ Reliability >0,995 confidence level 90%
- ❖ Demonstrated Service life > 28 years
- ❖ Modular Integration & compatible with Pyro-valve Brackets
- ❖ Low mass (<95g)
- ❖ Cost effective: no dedicated filter required in the propulsion system to comply with the ISO 24113 and French Space Act (no release of particles >1mm)
- ❖ Exclusion of Class1 & 9 for transport :

DSC-17-164606-05434A
PNEO-AgA 328/4

INERIS

Verneuil-en-Halatte, June 14, 2017

NO-CLASSIFICATION IN CLASSES 1 & 9 CERTIFICATE

❖ **Flight Models available in April 2018**

THANK YOU FOR YOUR ATTENTION

ANY QUESTIONS?

