



AIRBUS SAFRAN  
LAUNCHERS

# TPS Portfolio Status and Recent Developments

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# 1 / INTRODUCTION



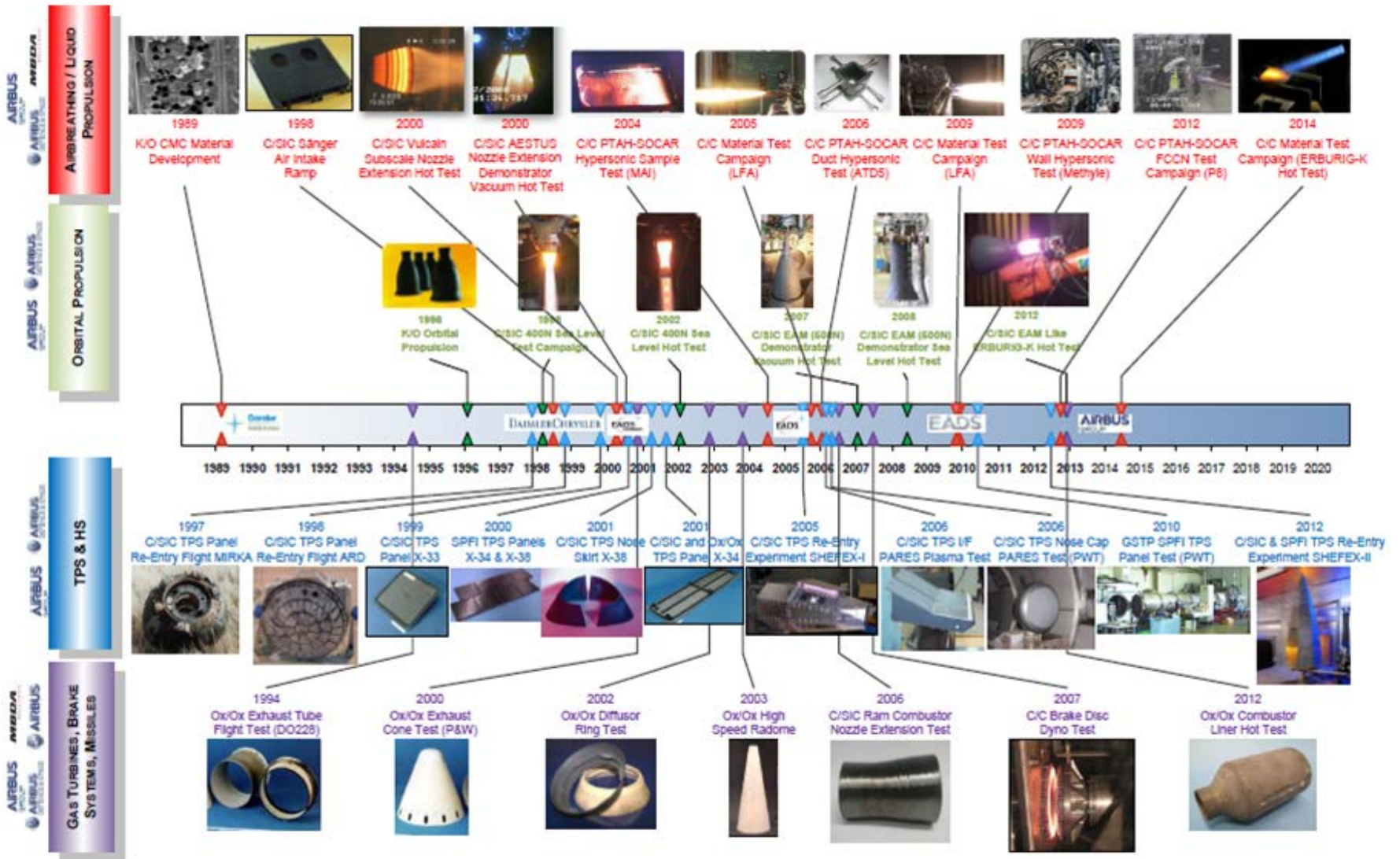
- Since the German hypersonic vehicle ,SAENGER‘ in the eighties ASTRIUM GmbH has developed a comprehensive portfolio of **Thermal Protection Systems (TPS)**
- In recent years the development has concentrated on detailed developments as well as continuation of development towards application on different vehicles
- Specific programs were HOPPER, PRE-X, ASTRA, FLPP M&S, PARES, EXPERT, IXV, SHEFEX I+II and CTV‘S like CARV, CSTS, BERT, ARV and ORION
- For demonstrators and experimental vehicles the development has focused on flexible, Met & rigid TPS
- In the frame of FLPP2 M&S a metallic TPS concept (MERIT) has been considered
- For the recent SHEFEX/REX program the entire spectrum of TPS was under consideration
- For the current ORION-ESM flexible TPS has been selected

# 1 / INTRODUCTION



- In particular the following AIRBUS GmbH TPS technologies were developed within the single programmes:
  - **HOPPER:** FEI, MetTPS, SPFI, C/SiC-TPS/HS
  - **PRE-X & IXV:** FEI, SPFI, C/SiC-TPS/HS
  - **ASTRA & FLPP M&S:** MetTPS (ULTIMATE & MERIT concepts)
  - **X-38 / TETRA :** FEI, C/SiC-TPS/HS
  - **PARES:** FEI, SPFI, C/SiC-TPS/HS
  - **SHEFEX I+II:** TPS experiments for MetTPS, SPFI, C/SiC-TPS
  - **EXPERT:** RTEI, IFI
  - **CTV's:** FEI, SPFI, C/SiC-TPS
  - **ORION MPCV –X TP:** FEI, MLI

# 1 / CMC Heritage at AIRBUS SL



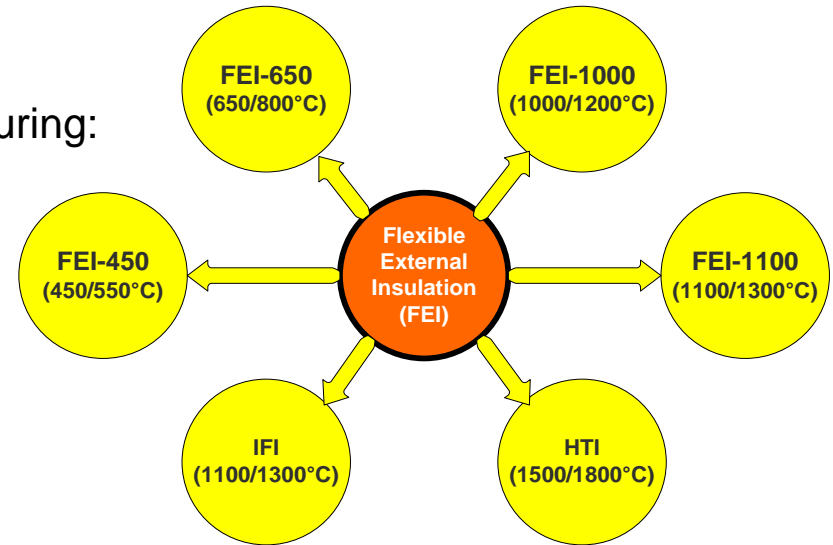
# 2 / FLEXIBLE TPS TECHNOLOGIES



## Flexible External Insulation (FEI):

leeward side Thermal Protection System (TPS) featuring:

- application temperature max. 300-1100°C
- FEI product family for optimum adaptation
- very low aerial weight
- comparably very low cost



# 2 / FLEXIBLE TPS TECHNOLOGIES



## Internal Flexible & High Temperature Insulation (IFI & HTI):

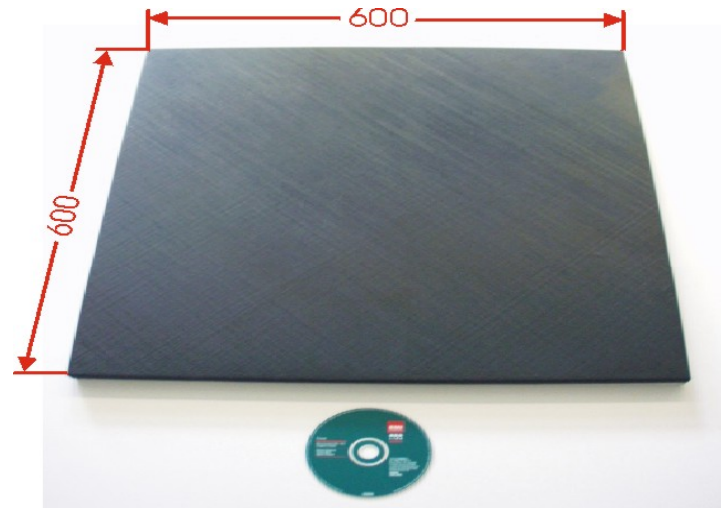
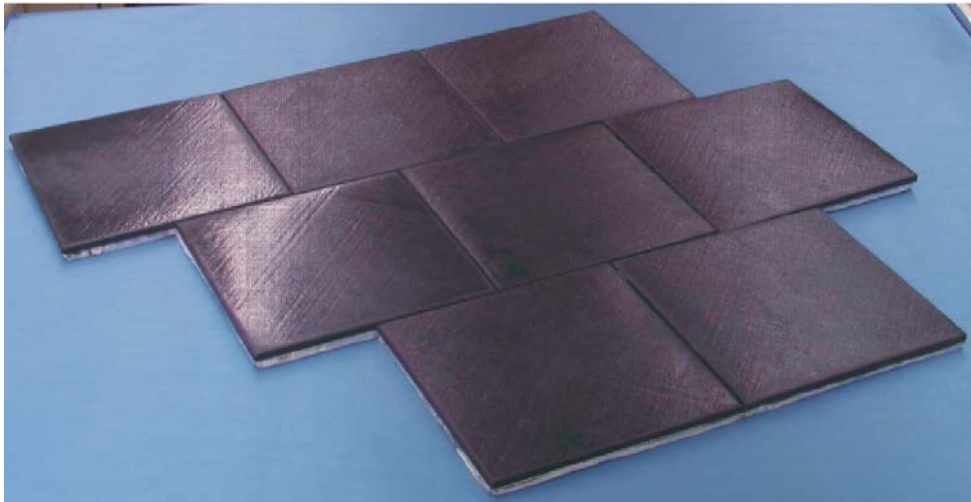
- TPS internal insulation featuring:
  - application temperature max. 1700°C
  - FEI based products
  - high thermal performance/low aerial weight
  - low cost





## Surface Protected Flexible Insulation (SPFI):

- windward side Thermal Protection System (TPS) featuring:
  - application temperature max. 1200°C
  - low aerial weight (~ 8kg/m<sup>2</sup>)
  - low cost
  - low maintenance effort

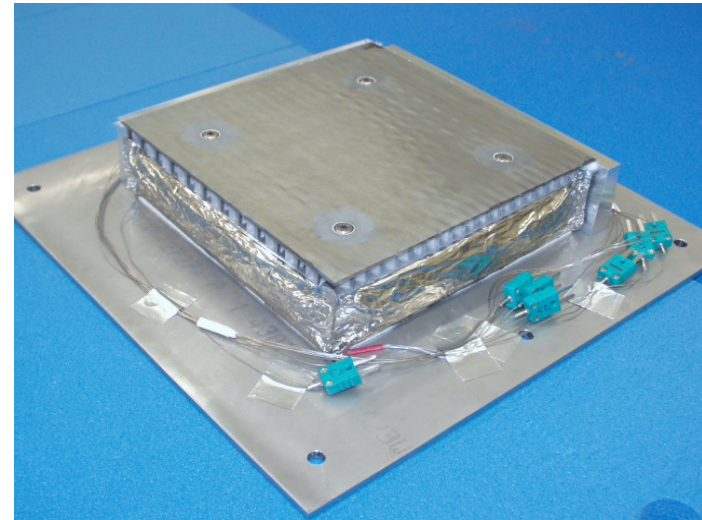
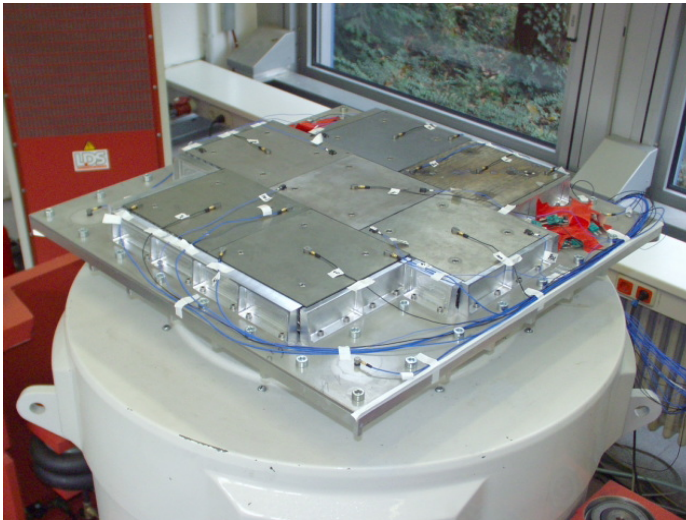






## Metallic Thermal Protection System (MERIT):

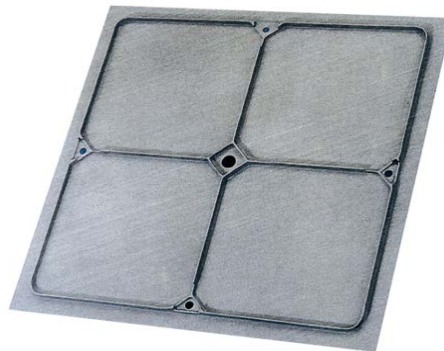
- windward side metallic Thermal Protection System (TPS) featuring:
  - application temperature max. 900°C
  - low aerial weight ( $< 10\text{kg/m}^2$ )
  - robust, simple to replace
  - low maintenance effort





## CMC Thermal Protection System:

- windward side fibre reinforced ceramic Thermal Protection System (TPS) featuring:
  - Ox & C/SiC ceramic
  - application temperature > 1600°C
  - low aerial weight
  - robust
  - elevated heat flux capability





## UHTC based Thermal Protection System (SMARTEES):

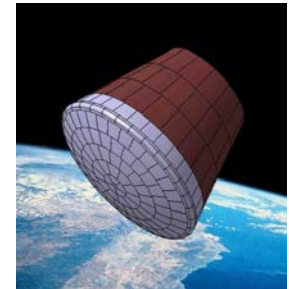
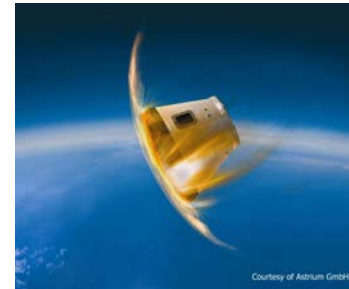
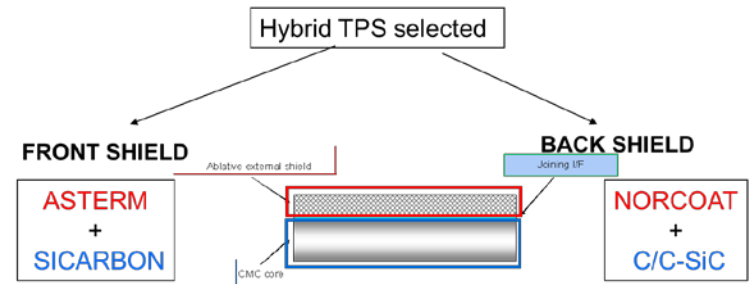
- windward side stand-off panel TPS featuring:
  - UHTC composite & C/SiC ceramic outer layer
  - TI S/O's
  - application temperature > 1600°C
  - low aerial weight
  - Robust, reusable TPS
  - elevated heat flux capability
- ASL has contributed to this development and was acting as LSP (end user)
- Proof of concept performed in FP7 incl. verification of major loads/environments





## Combined Ablative / ceramic material based hybrid Thermal Protection System (HYDRA):

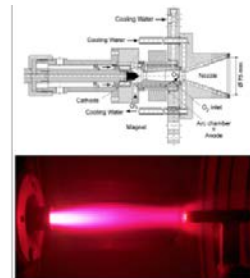
- windward side stand-off panel TPS featuring:
  - Ablator & C/SiC ceramic outer layer
  - TI S/O's
  - application temperature > 1600°C
  - low aerial weight (mass saving up to 43%)
  - Robust (outer surface ablative material)
  - elevated heat flux capability (up to 6 MW/m<sup>2</sup>)
- ASL has contributed as partner to this development and was acting as LSP (end user)



Thermal shock furnace at INCAS



Indutherm facility (DLR)



Plasma Wind Tunnel (PWT)



# 4 / DEVELOPMENT PROGRAMMES



## X-38

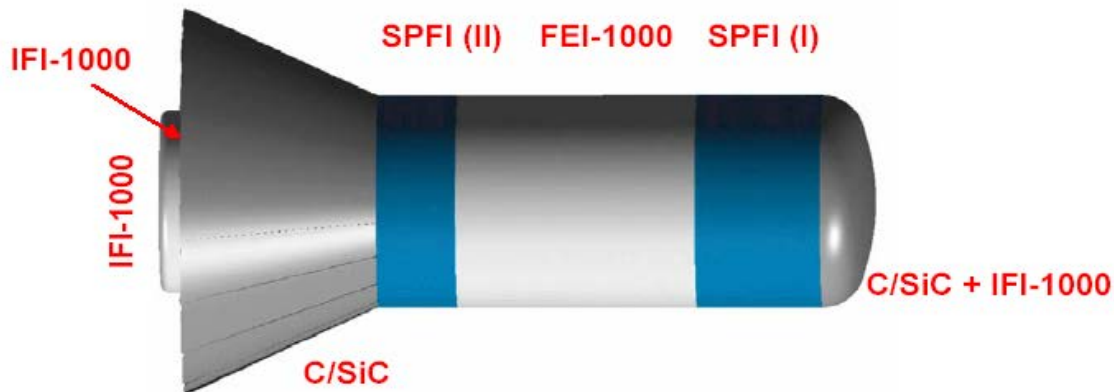
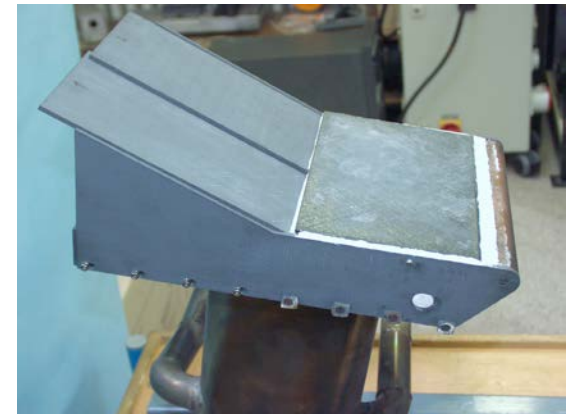
- Cooperation between NASA, ESA & DLR
- Design, analyses, sizing, qualification testing, manufacturing, delivery & integration (entire cycle)
  - FEI – 450 / 1000 Blanket TPS
  - HTI & IFI for hot structures
  - C/SiC nose skirts





## PARES

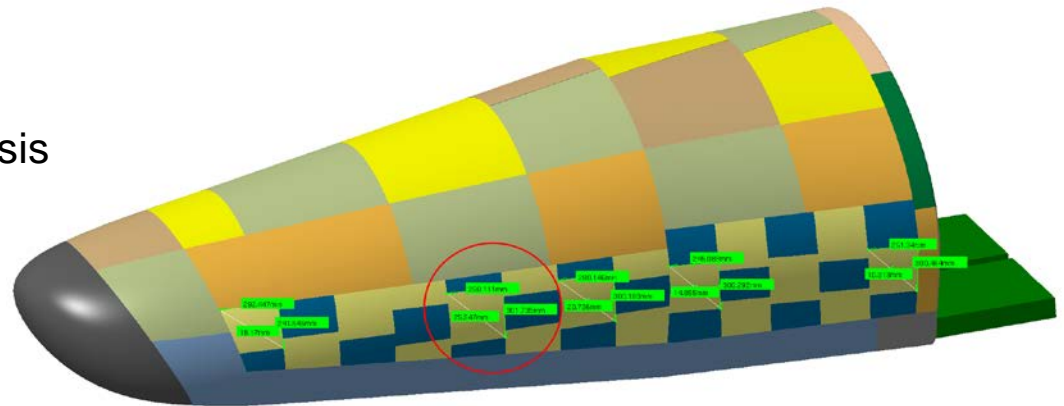
- Design & TPS sizing during phases B1 and B2 of the program
  - Blanket TPS
  - CMC panel TPS
  - C/SiC nose
  - Stabilizer
- Development of CMC TPS towards elevated temperatures
- Flight TPS Instrumentation





## GSTP-SPFI TPS Development

- Delta development for IXV application (increase of TRL to 6)
- Panel I/F (sealing) development
- Development of thick panels
- Verification by analysis
  - Thermal analysis
  - Thermo-mechanical analysis
  - Venting analysis
- Manufacturing of test samples
- Verification by tests
  - Vibration test
  - Thermal IR test
  - Plasma wind tunnel test





## MetTPS Development

- Development performed within
  - National program (ASTRA) → ULTIMATE concept
  - ESA FLPP M&S program → MERIT concept
- ULTIMATE → gammaTiAl based (favoured in view of mass)
- MERIT → beta Ti based
- Design concept for both nearly identical
- Aimed for medium temperature range (< 900°C)
- Lightweight TPS (aerial weight < 10kg/m<sup>2</sup>)

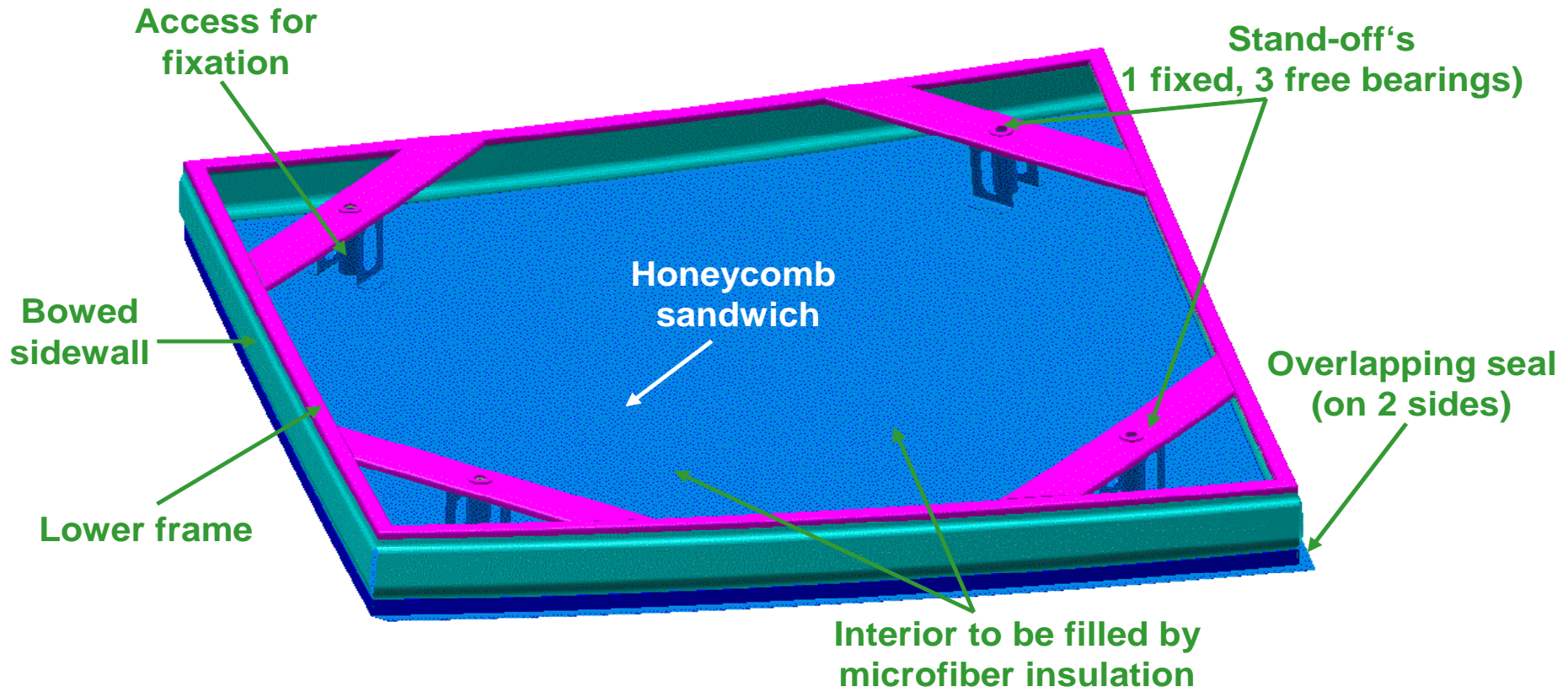


# 4 / DEVELOPMENT PROGRAMMES



## MetTPS Development

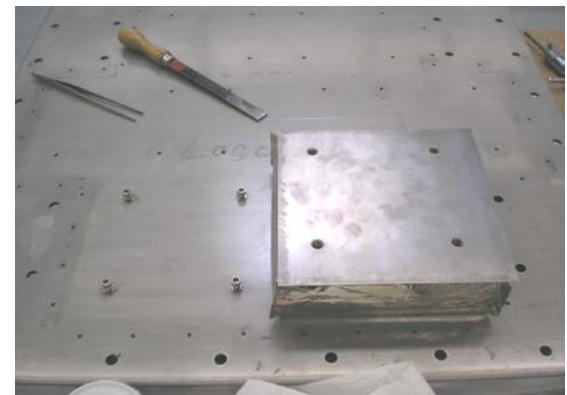
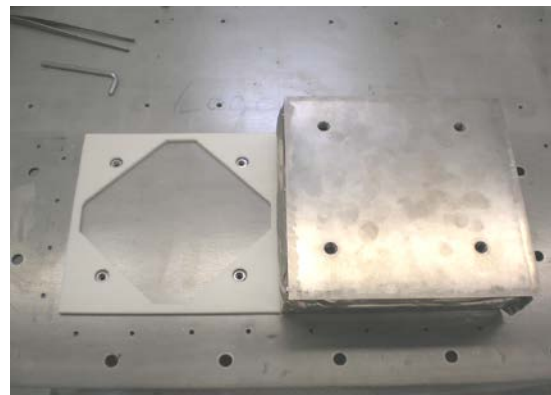
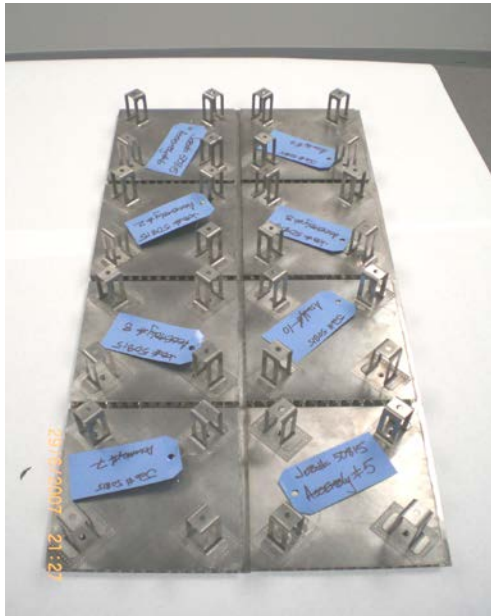
Metallic TPS Design Concept



# 4 / DEVELOPMENT PROGRAMMES

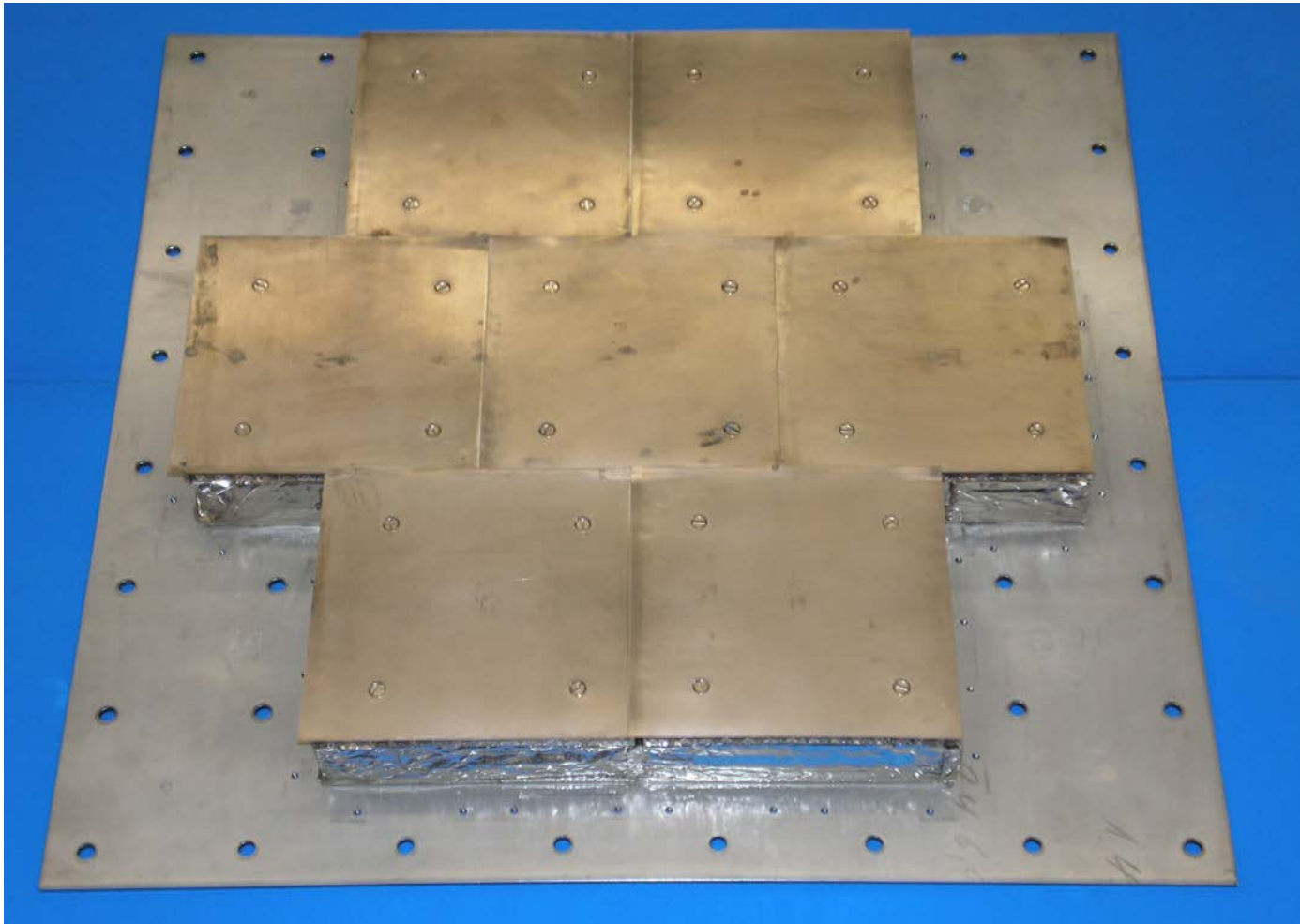


## MetTPS Integration





## MERIT Metallic TPS Demonstrator

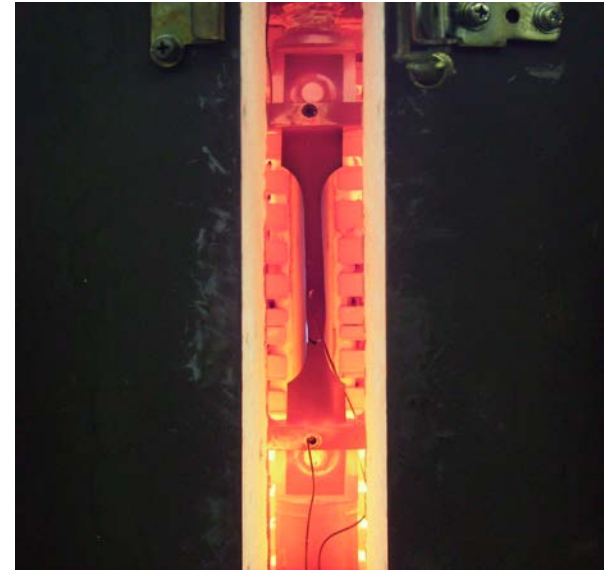


# 4 / DEVELOPMENT PROGRAMMES

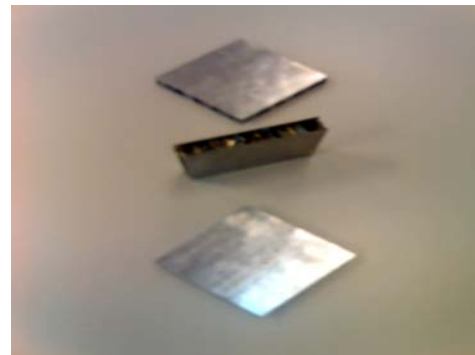


## MetTPS Development

### Characterization Tests



*Tensile*



*Compression*



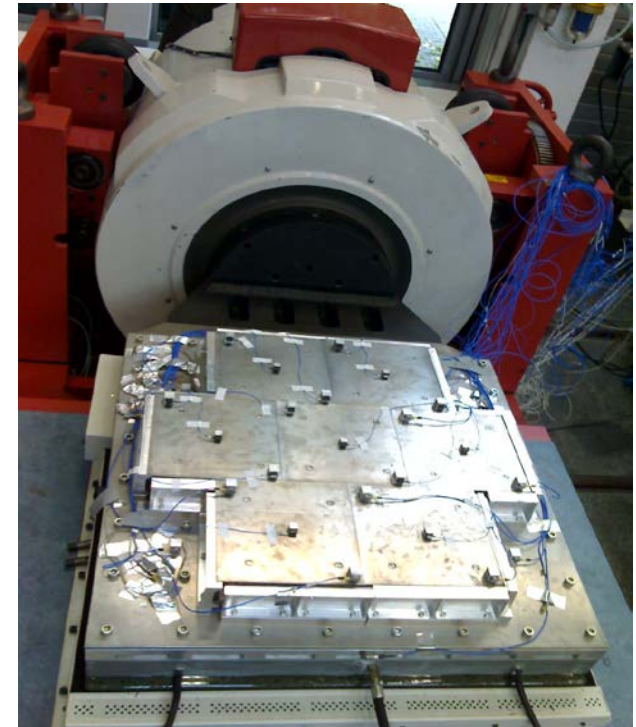
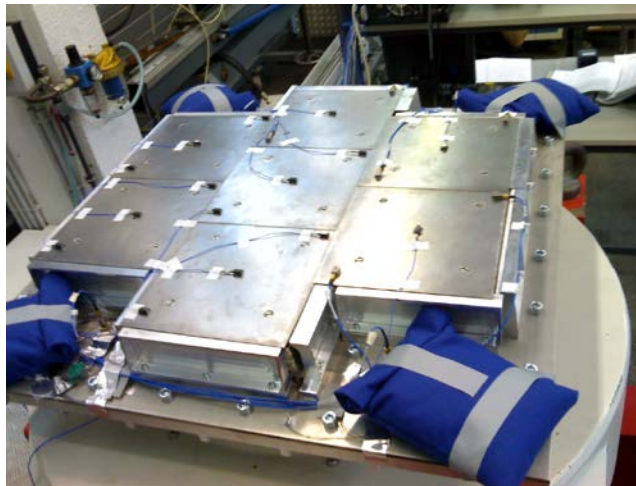
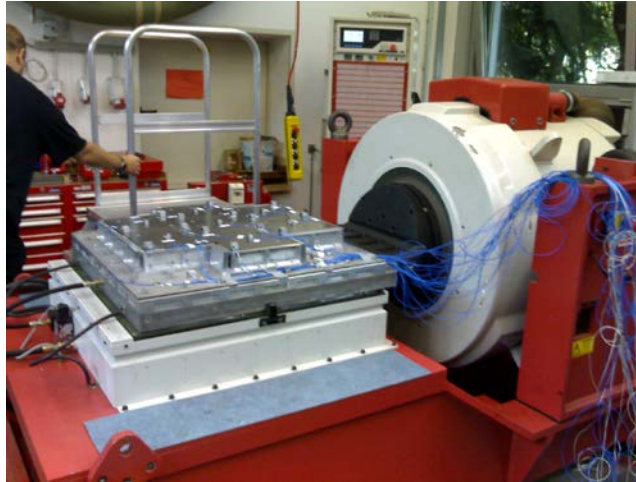
*Bending*

# 4 / DEVELOPMENT PROGRAMMES



## MetTPS Development

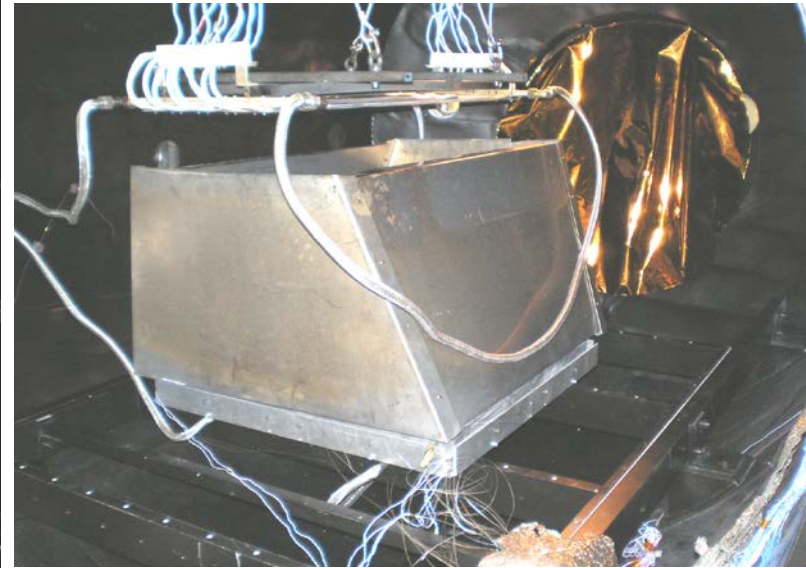
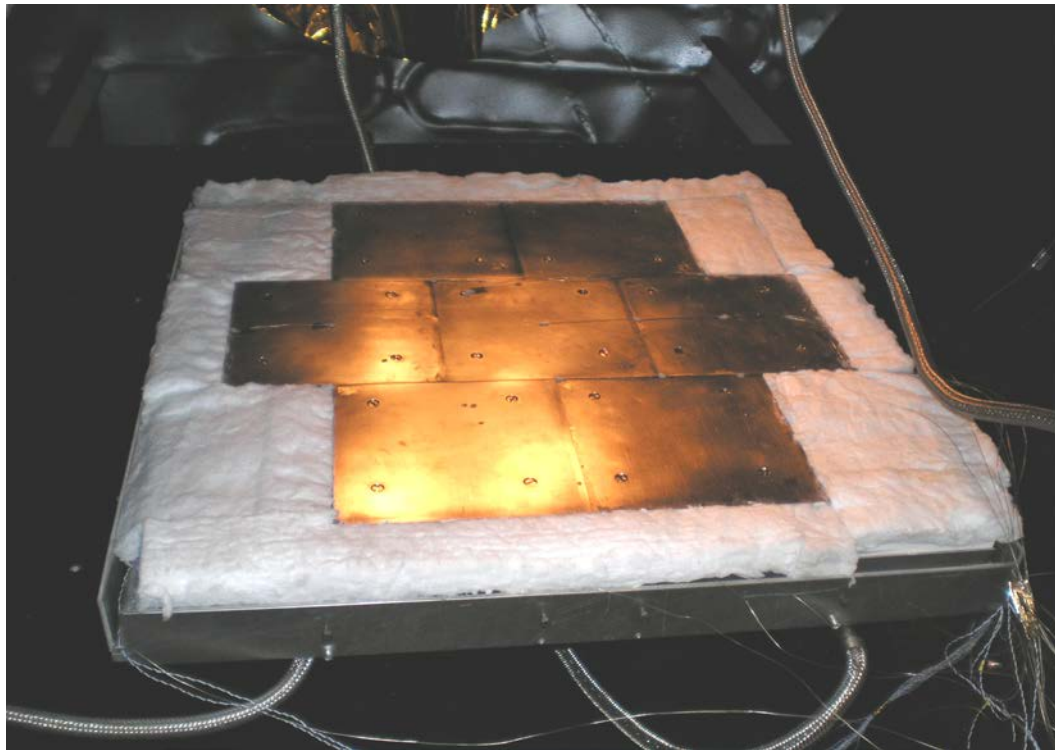
### Sine Sweep & Random Vibration Test





## MetTPS Development

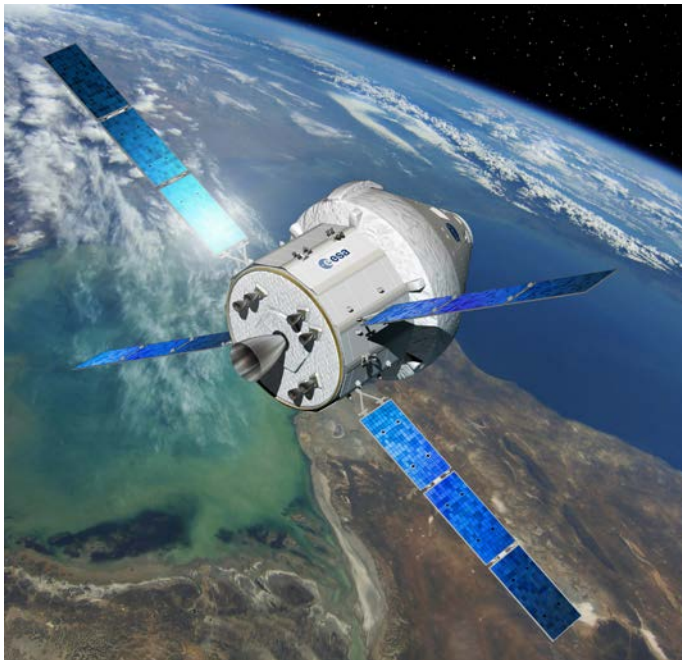
### Thermal Cycle IR Test





## ORION ESM -X TP

- The Thermal Protection (-X TP) covers the ORION MPCV-ESM aft bumper and housing, the AUX Thruster I/F and the OMS-E areas
- The major purpose of this TP are as follows:
  - To protect the aft bumper and its equipments from high thermal fluxes
  - To keep the aft bumper Temp at max. 60°C



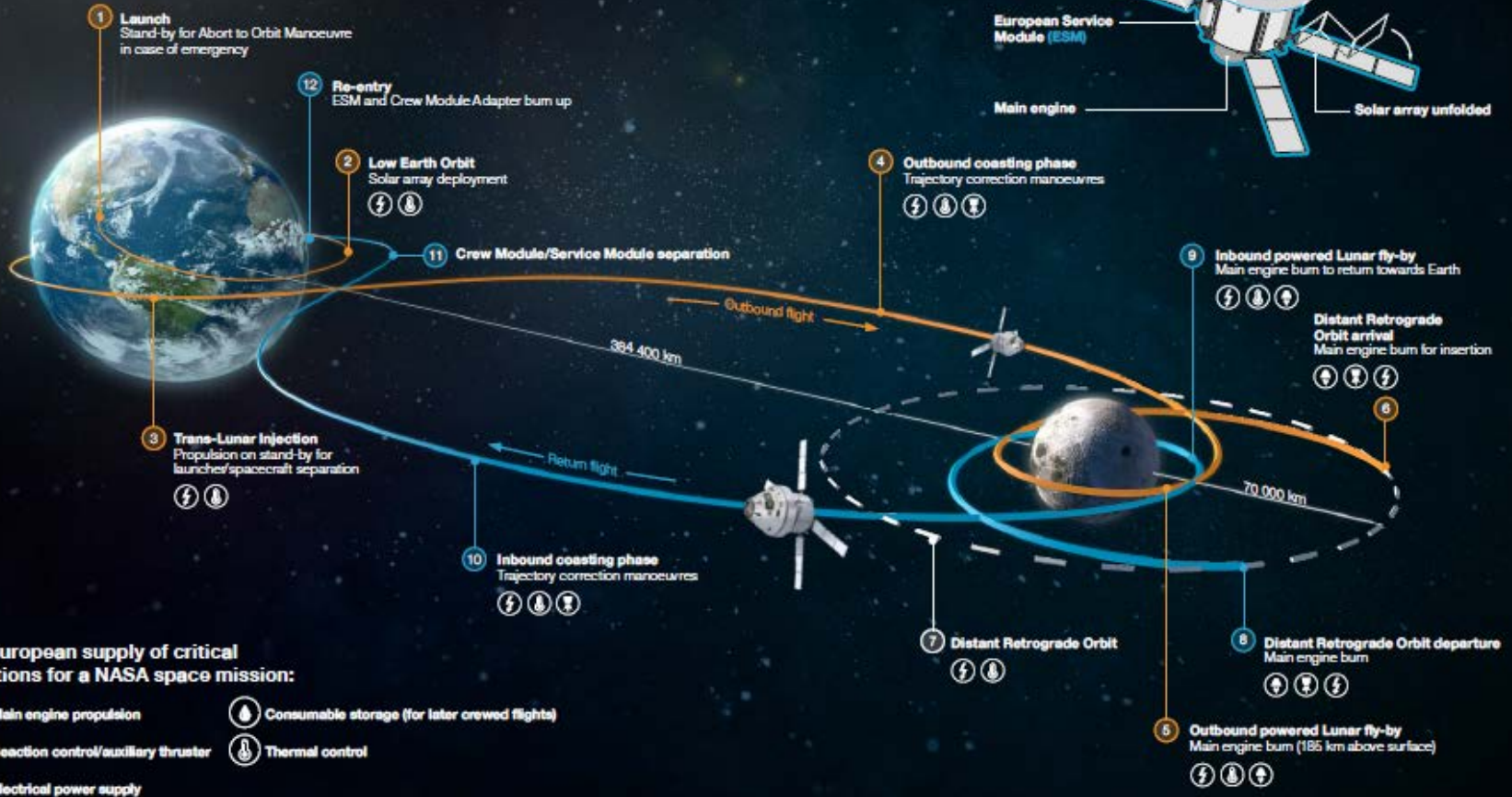
# 4 / DEVELOPMENT PROGRAMMES



## Journey around the Moon powered by Airbus DS

While travelling around the Moon and back on its first mission (EM-1), the unmanned NASA Orion spacecraft will demonstrate its systems and high speed entry performance prior to crewed flights. Under an ESA contract, Airbus Defence and Space is building the **European Service Module (ESM)** that will power the spacecraft and hence provide critical functions during the whole mission:

Orion spacecraft and ESM



**1st European supply of critical functions for a NASA space mission:**

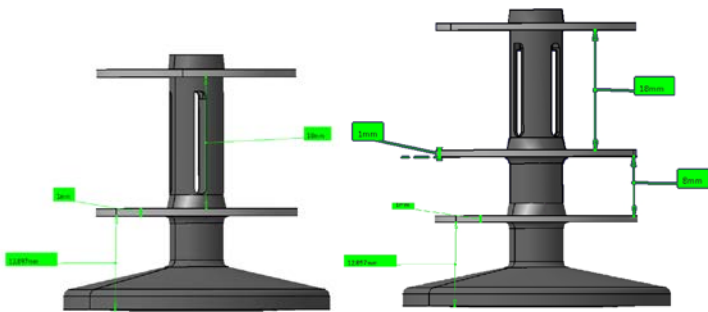
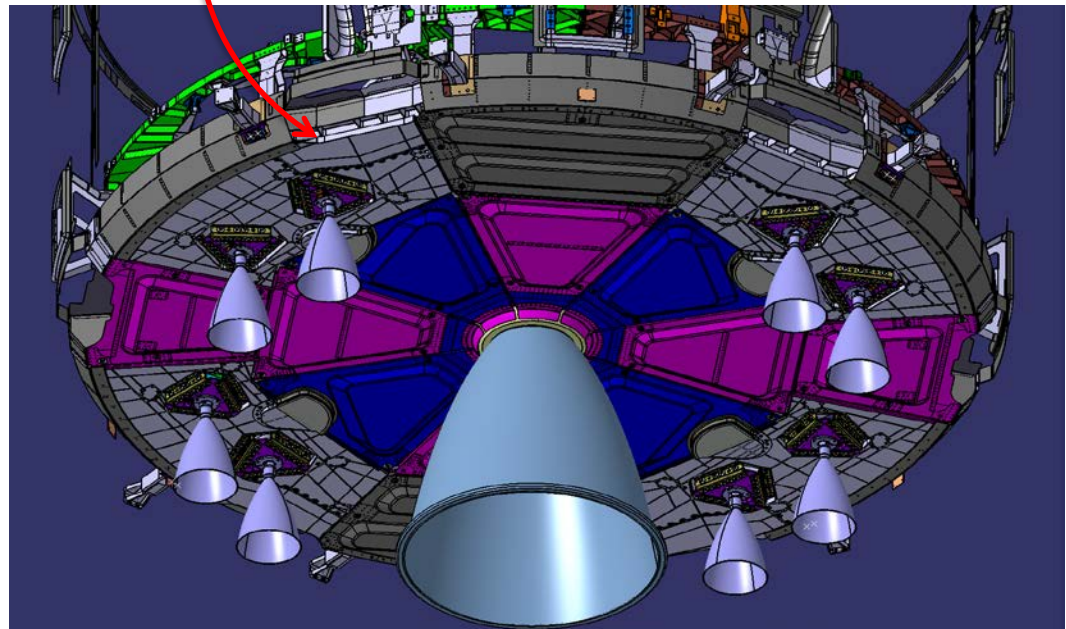
- Main engine propulsion
- Consumable storage (for later crewed flights)
- Reaction control/auxiliary thruster
- Thermal control
- Electrical power supply





## ORION ESM –X TP

- TPS Design
- Fixation Item Design
- Thermal and Mechanical Analysis
- Thermal Qualification Testing
- TPS Manufacturing
- Delivery & Integration



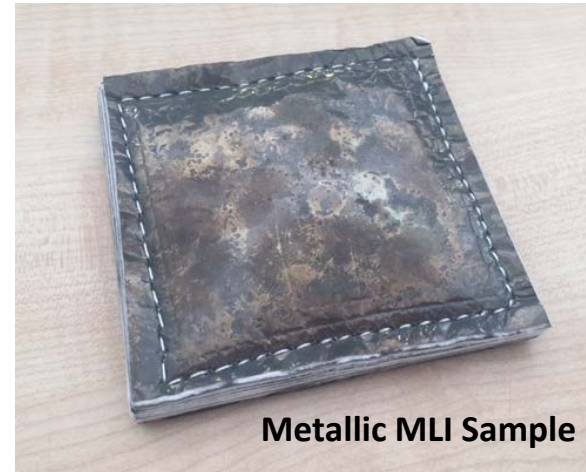
**Fixation Design**



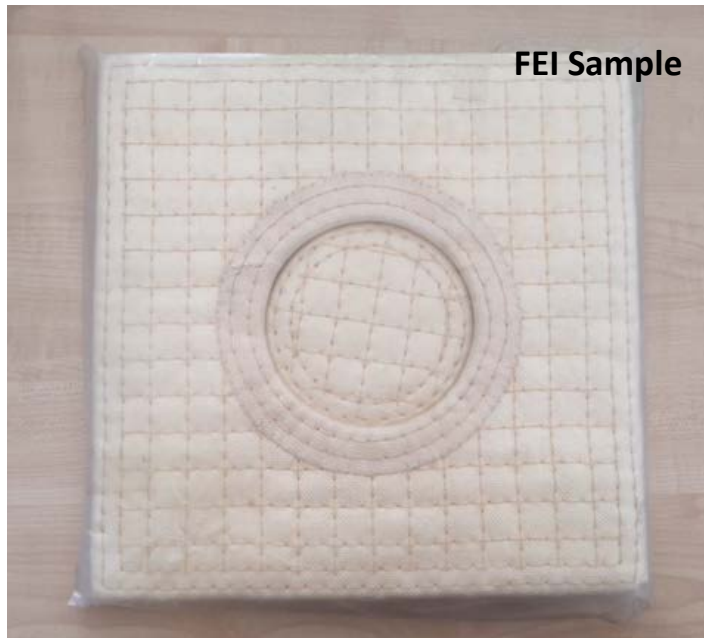
## ORION ESM -X TP

➤ The -X TP consist of:

- FEI
- Kapton MLI
- Metallic MLI (AUX areas)



**Metallic MLI Sample**



**FEI Sample**



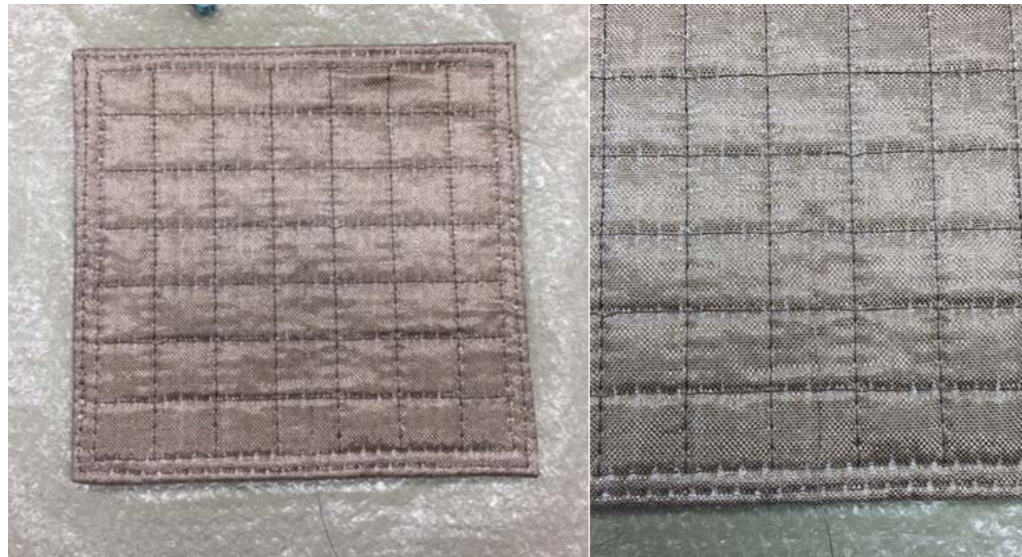
**Kapton MLI Sample**



## ORION ESM –X TP

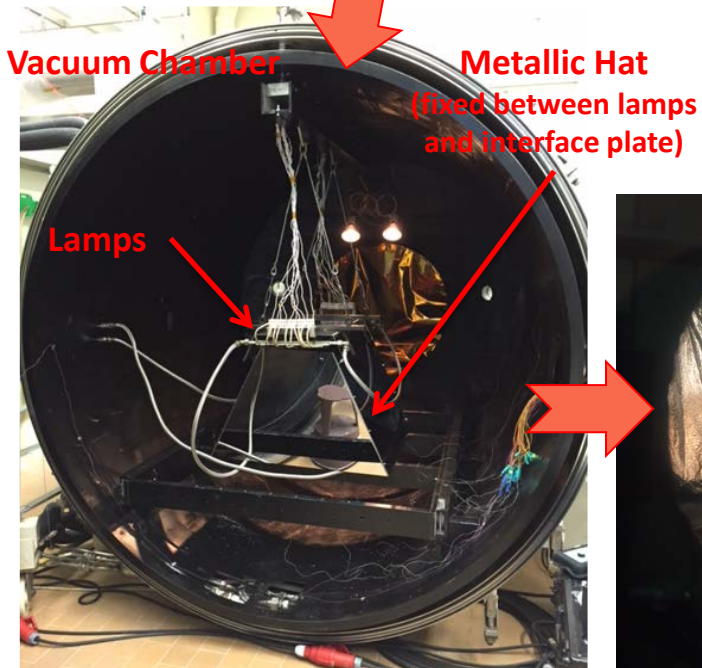
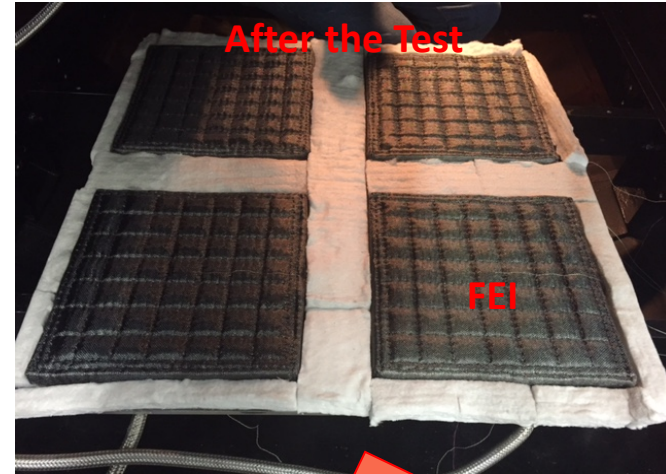
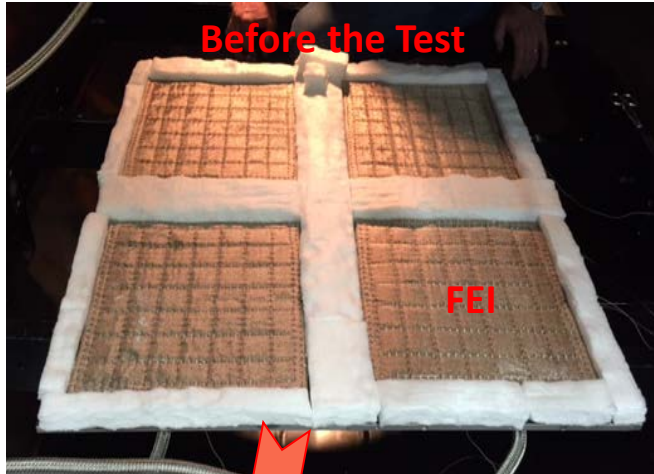
### Thermal Qualification Testing for FEI blankets:

- Test results verified the sufficient performance (thermal/integrity) for the application of FEI on ORION MPCV-ESM –X TP
- The FEI is quilted blanket based on:
  - Ceramic fabric
  - Thread
  - Core components



**FEI Test Samples**

# 4 / DEVELOPMENT PROGRAMMES



# 5 / FLIGHT EXPERIMENTS



## SHEFEX I + II TPS EXPERIMENTS

## SHEFEX I (Mach ~7)



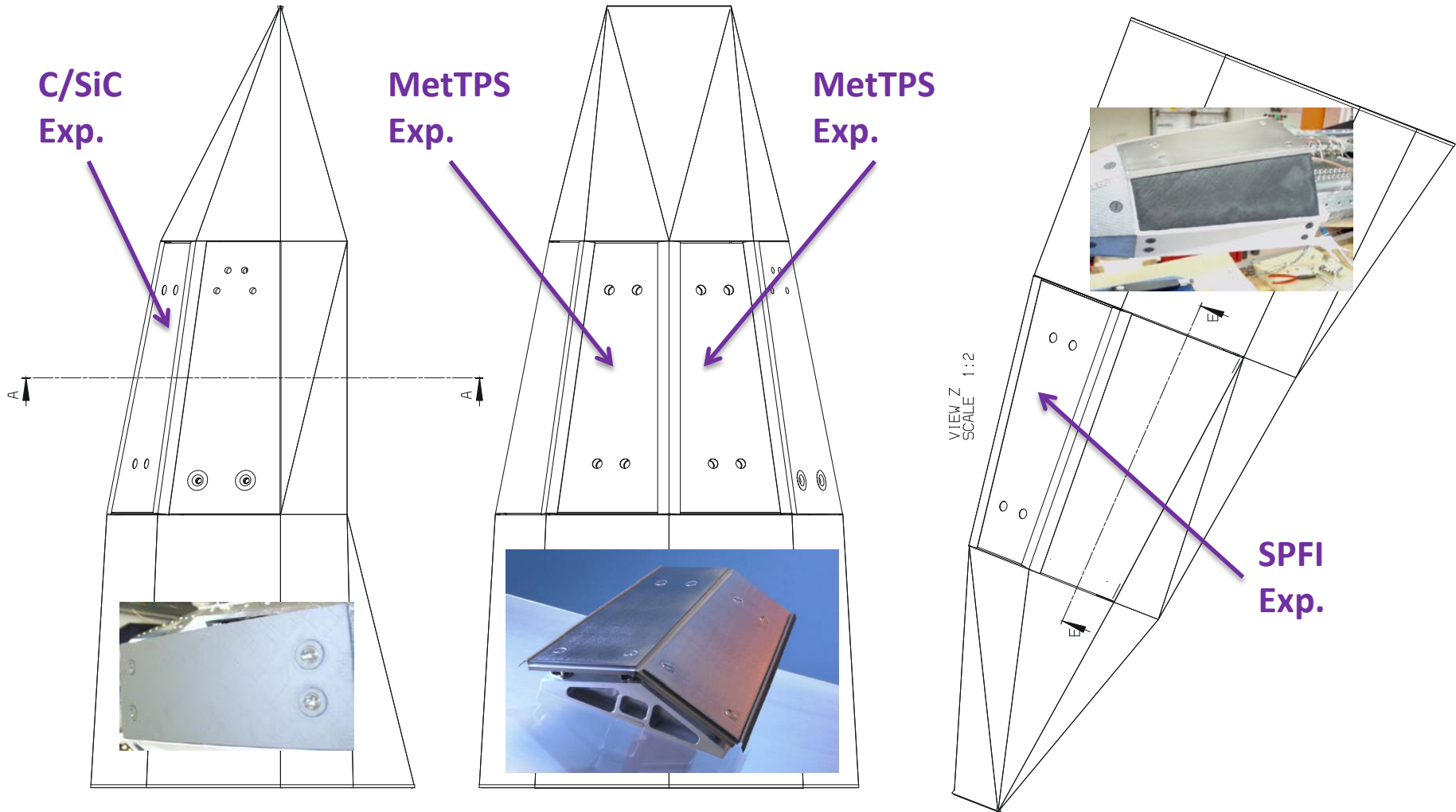
## SHEFEX II (Mach ~12)



# 5 / FLIGHT EXPERIMENTS



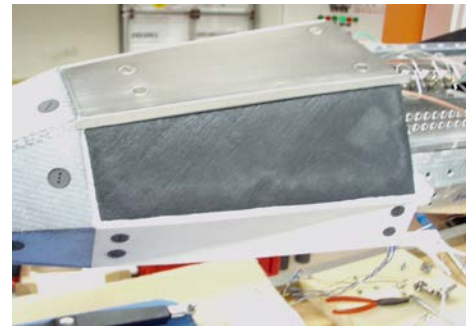
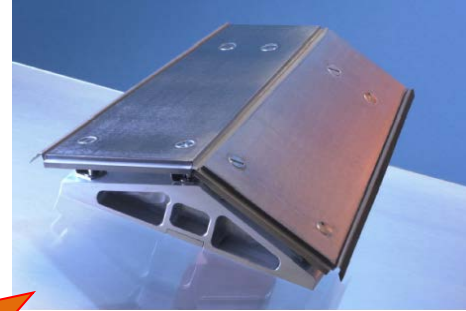
## SHEFEX I TPS EXPERIMENTS



# 5 / FLIGHT EXPERIMENTS



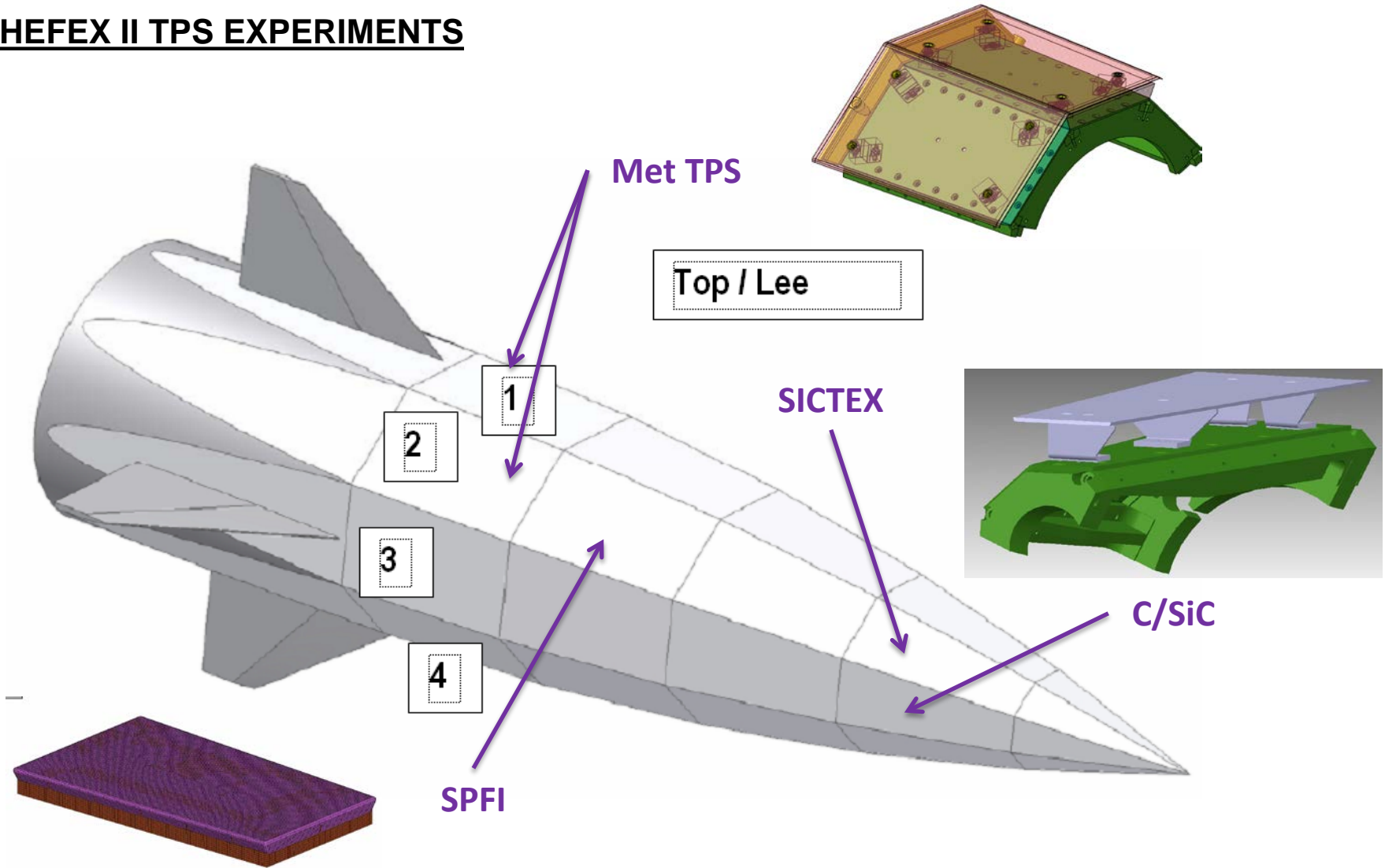
## SHEFEX I TPS EXPERIMENTS



# 5 / FLIGHT EXPERIMENTS



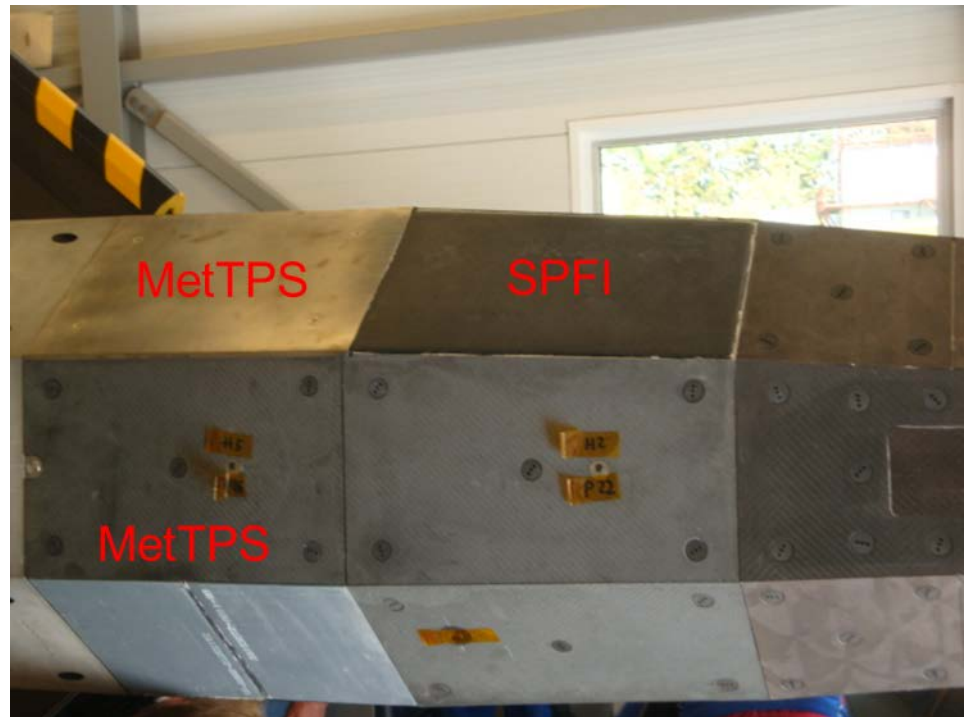
## SHEFEX II TPS EXPERIMENTS







## SHEFEX II TPS EXPERIMENTS LAUNCH PREPARATIONS



# 6 / CONCLUSION



- AIRBUS SL GmbH has developed the largest portfolio of non-ablative TPS in Europe
- AIRBUS SL GmbH has been involved in nearly **all** national and ESA re-entry programmes as well as in some NASA & JAXA programs
- Large experience available in all TPS engineering disciplines
  - Analysis / sizing
  - Lay-out / design
  - Material Testing
  - Components & Assembly Testing
  - Wind tunnel & Flight Experiments
  - Integration & Assembly
  - Application on SV
- To gain operational flight experience is the major challenge for the future



## Acknowledgements

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**German Space Agency (DLR)**  
within the frame of the ASTRA, TETRA & SHEFEX Programs.

Others were funded by the FLPP2 program directed by **ESA**  
or FP7 program directed by **EU**.



# THANKS FOR LISTENING