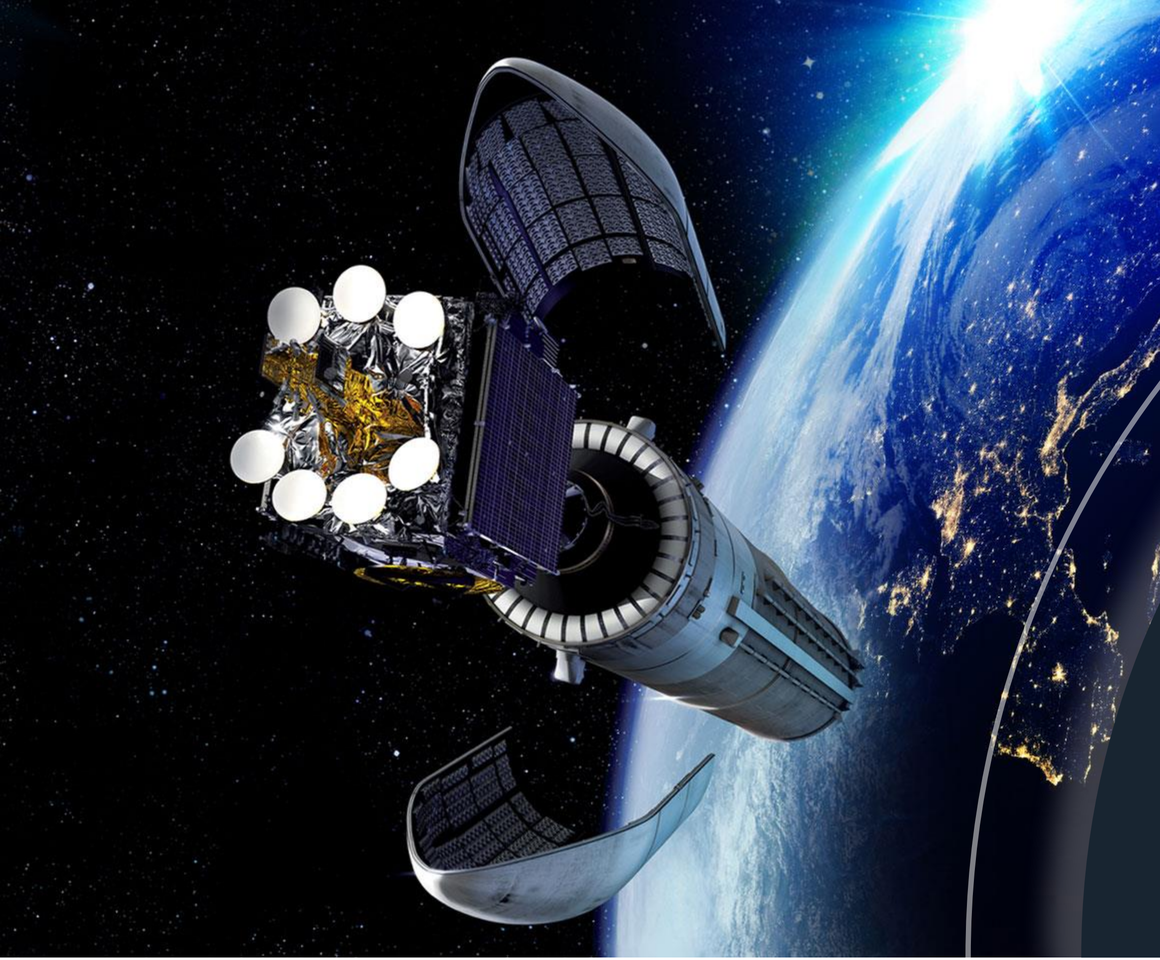


Innovation Triangle Initiative
Demisable Joint

CleanSat Industrial Days

ESA/ESTEC October 23-25 2018

ThalesAlenia Space
a Thales / Leonardo company

ITI, Innovation Triangle Initiative - Demisable Joint study team

Lilith Grassi - Study manager and WPs manager

Simone Bianchi – WPs manager

Thorn Schleutker - DLR study manager

Alexander Ruf - Facility technician

Mirko Piloni - Responsible cryogenic & special test department

Claudio Sampietri - Support and coordination to static facility tests

ITI Study - context and reasoning

- Previous **D4D studies at system level** have clearly shown that, to reduce the risk posed by re-entering satellites, an **integrated approach** to design for demise is more efficient or, for large satellites, even required.
- Solutions at component or equipment level might not be enough to effectively reduce the re-entry casualty risk, and that **a system-level approach is almost invariably better,** or even necessary.
- The **early break-up** of the spacecraft main structure or the early separation of critical payloads, can **significantly reduce the casualty risk** on ground.

Proposed solutions to allow an early break up of satellites structure and payload separation:

- Active Technologies (Dismantling by induction, Pyro system separation screw, Exothermic additives, etc.)
- Passive Technologies (SMA, Negative thermal expansion material, Epoxy adhesive, etc.)
- Demisable Joining Technologies (welding, epoxy, etc.)

→ S/C implement a very large number of joints.

→ Needs of a **solution simple, low cost and with little impact on the overall configuration**

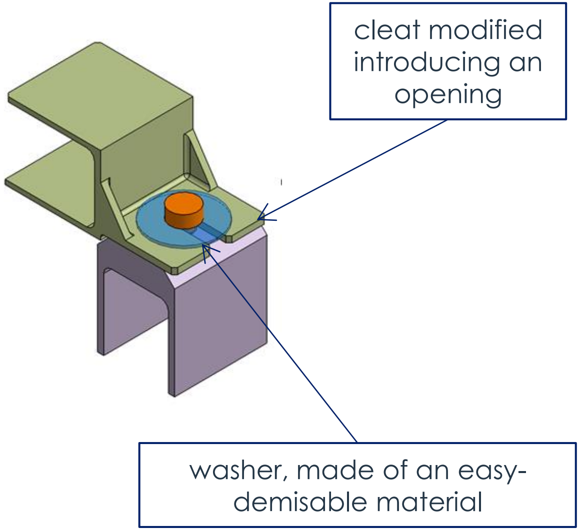
Study goal

The goal of the study is to test the Demisable Joint demonstrating that it allows an early separation of the spacecraft external panel in order to improve the overall demisability and to reduce the casualty risk on ground.

- This goal will be achieved through detailed **test campaigns simulating the re-entry environment** in terms of both aero thermal and mechanical loads.

- Main steps of the study:
  - **Task1:** detailed **re-entry environment definition**
  - **Task2: breadboard** design and manufacturing
  - **Task3: tests** execution adopting in synergy both thermo mechanical test and plasma wind tunnel test
  - **Task4: roadmap** definition

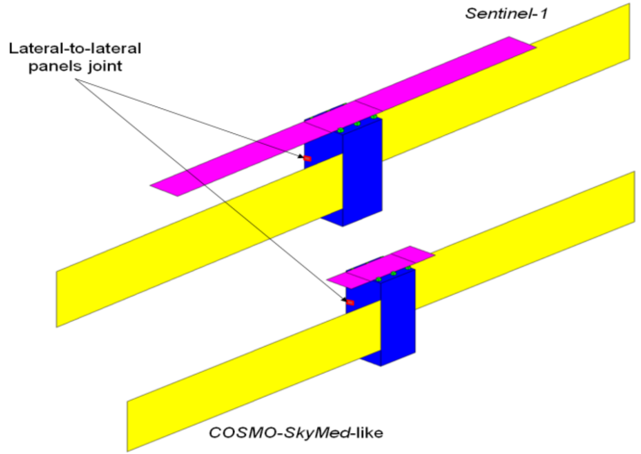
The Demisable Joint, is based on a standard Aluminium joint in which two modifications are implemented

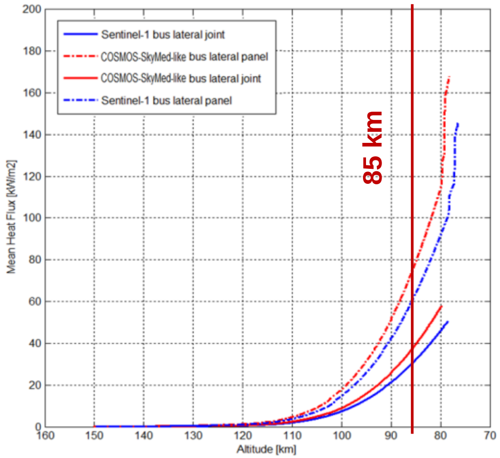


TASI Patent (patent N.TO2014A000998) by TAS-I as *Passive Device Designed to Facilitate Demise of a Space System During Re-entry into the Earth's Atmosphere.*

Task 1 - Test definition: Re-entry conditions definitions

- In order to successfully test the demisable joint, the knowledge of the environmental conditions is essential.
- Define re-entry thermal, aerodynamic and mechanical loads
- Define the test plane

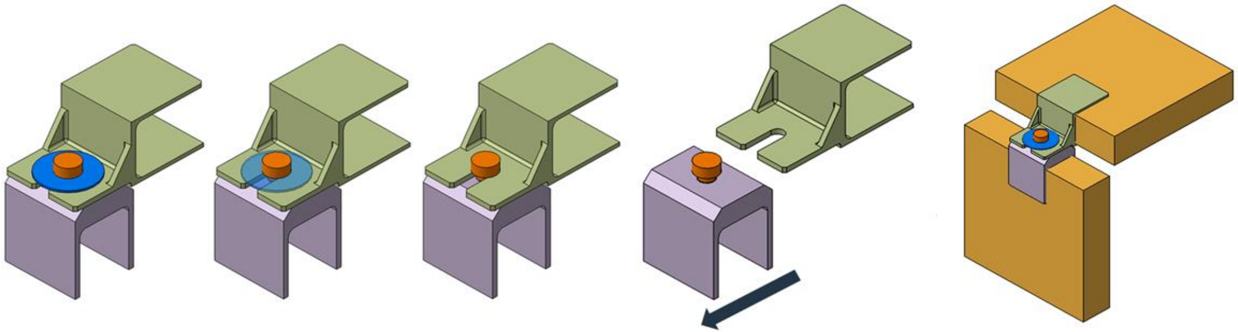




Sentinel-1 and COSMOS-SkyMed-like mean heat flux on lateral panels and lateral panel joints evaluated with TADAP (TAS-Ini destructive re-entry tool)

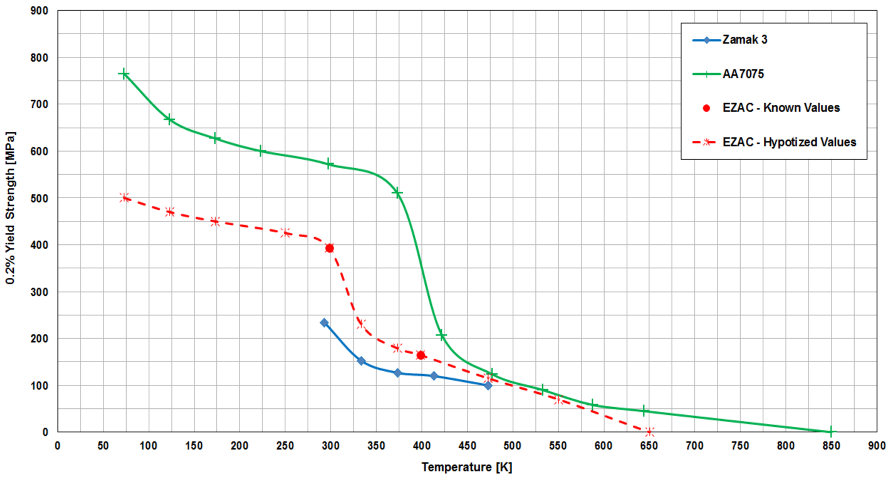
Task 2 – Test sample definition: DJ design

- During the operative life, the demisable washer (blue item) acts a usual washer in the joint assembly
- During re-entry as consequence of the aerothermodynamic loads, the washer heats very fast **reaching the melting point earlier than the other items** of the joint assembly.
- Near the washer melting temperature, the washer can both be disintegrated by ablation or be broken by the structural loads
- Once the washer has demised, the **cleats can have a mutual shift**, leading to the joint dismantlement.



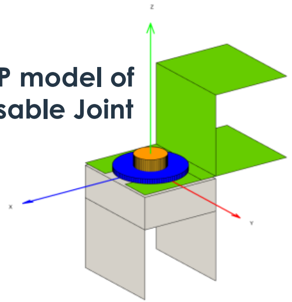
Demisable Joint based on a demisable washer – Baseline Design and Principle of funtioning

Task 2 – Test sample definition: Washer design and material



AA7075, EZAC and Zamak 3 yield strength vs temperature

TADAP model of Demisable Joint



Washer design prosed trade-off

Name	Composition	Density	Heat Capacity	Melting Temperature	Melting Enthalpy	Emissivity Coefficient	Conductivity	Yield Strength	Heat of Demise
[-]	[%]	[kg/m³]	[J/kg/K]	[K]	[J/kg]	[-]	[W/m/K]	[MPa]	[KJ/kg]
EZAC™	Al 9.0-18.0 Cu 4.0-6.0	6600	460	670	120000	0.200	120.0	396	290

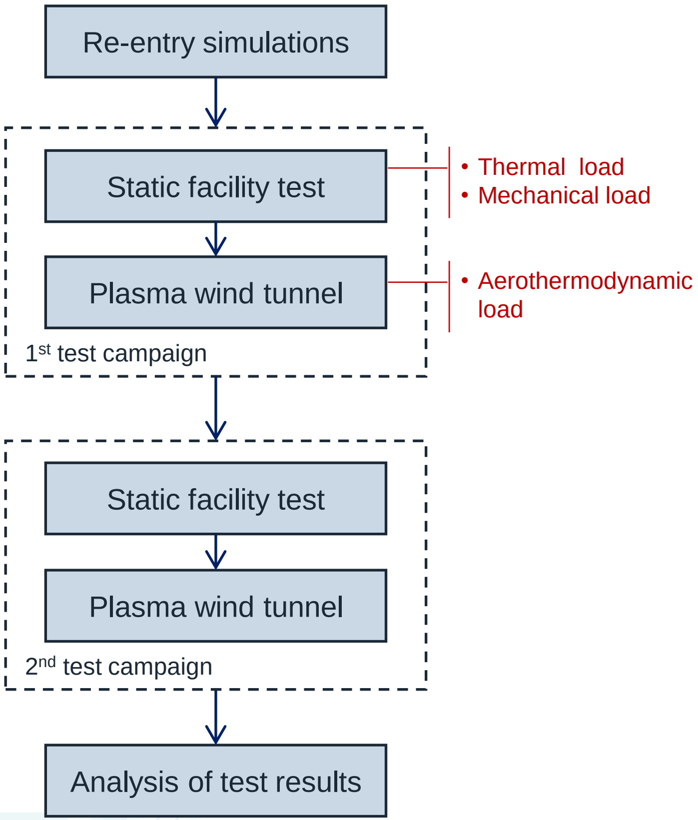
Washer material

Task 3: Test execution - Demisability Test approach

- the tests have to represent at the maximum extent the re-entry environments in terms of:
  - **Thermal loads** (overall and vs. time)
  - **Aerothermodynamic loads** (overall and vs. time)
  - **Mechanical loads** (overall and vs. time)

- there are no facilities able to reproduce all these aspects together at the same time, needs of an **integrated approach to testing**:
  - Tests on a **static facility** able to **reproduce at the same time the temperature and mechanical loads profile** will allow to evaluate the impact of loads on the separation altitude
  - **Plasma wind tunnel** tests, (with the possibility of applying a static load to the joints) will allow to reproduce the **aerothermodynamic loads**

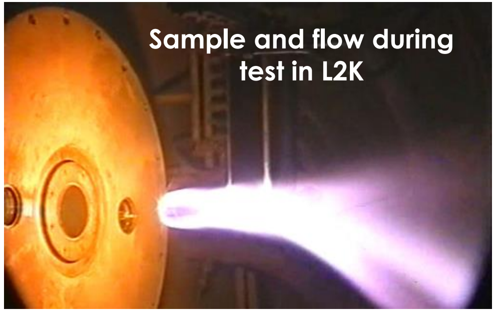
- The two typologies of test will be performed in parallel and in an **iterative** way



Task 3: Test execution – facilities

Plasma wind tunnel test:

- test will duplicate **total heat load and average dynamic pressure** of the selected trajectory phase, **additional tests with a dynamic heat flux and pressure profile** will be conducted to check the impact of the transitional surface loads on the demise behaviour


Sample and flow during test in L2K

Static facility thermo mechanical test: A stress rupture based test campaign will be conducted in the ***element*** facility.

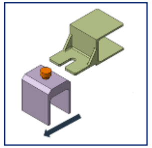
- To apply the **mechanical incremental forces,** two possible options:
  - Tensile force
  - Compression force
- For the **increment of the temperature** the laboratory, two possible systems:
  - Furnace
  - Induction system


Furnace and testing machine frame

Test set-up	Heating system	Max T	Maximum rate	Mechanical load
#1	Furnace	1200°C	Ramp to arrive at 600°C is about 20 minutes	Tensile force
#2	Furnace			Compression force
#3	Induction system	>1200°C	The induction system permits a large ramp of heating (fast or slow). Detail of the ramp depends on the combination of the coil and the Kind of material to be heated	Tensile force
#4	Induction system			Compression force

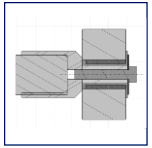
Task 4: Conclusion and roadmap

ITI goal



Prove that **a single joints** separates at high altitude

future goals



Apply washer concept to **other typologies of joints** and prove that separates at high altitude

Prove that the substitution of current joints with the demisable ones causes an **early break-up of the S/C →** separation of panels considering the overall satellite configuration.

Prove that it **works as joint:** structural and thermal analysis, performance tests

Thank you

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