Demisable Joint

Cleansat Industrial days

ThalesAlenia Space
a Thales / Leonardo company

WHY an early break up

- Previous **D4D studies at system level** have clearly shown that, in order 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.

- Re-entry simulations demonstrated that 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 (in particular if adopted in combination with re-designed critical elements), or the early separation of critical payloads, can improve the overall demisability, significantly reducing the casualty risk on ground.

WHY an early break up

Achievable CA reduction - Sentinel -1 impact on demisability of critical components (current and redesigned) of an early break-up system

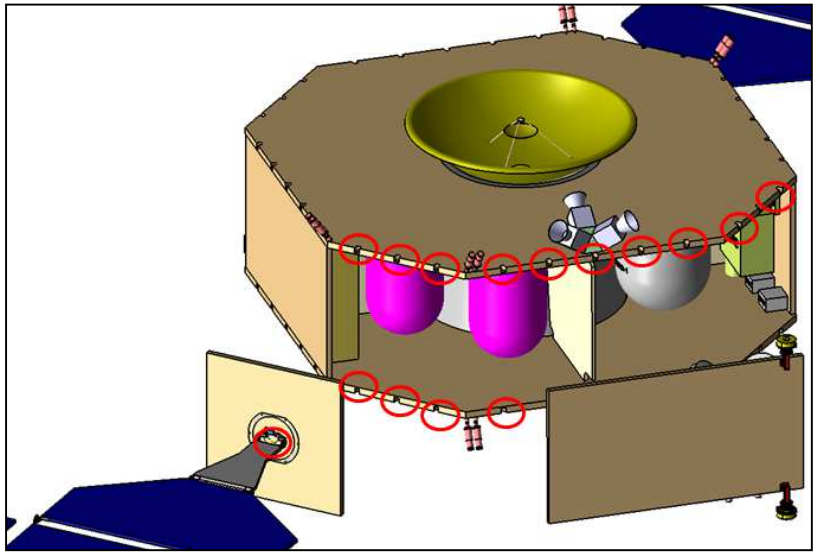
Component	D4D main Strategy	Needs of combination with early exposure to the flux	Achieved CA reduction (relative to the component)	Potentially achievable CA reduction (relative to the component)	Potentially achievable CA S/C reduction
Redesigned Al Li tank	Material Swap	Yes (early structural panel separation)	100 %		12%
Redesigned Al RWs	Material Swap	Yes (early structural panel separation)	35%	100% (Relocation lead to complete demise)	17%
Current MTQs	Increase heat flux	Yes (early structural panel separation or relocation)	100 %		10%
SAR	Increase heat flux	Yes (payload early separation)	50%	80% (Increasing separation altitude at about 85-90 km)	42%

WHY a passive solution, WHY a Demisable Joint

- Several solutions have been proposed, and are currently being studied, to allow an early break up of satellites structure and payload separation. These solutions can be classified as:
  - Passive Technologies (SMA, Negative thermal expansion material, Epoxy adhesive, etc.)
  - Active Technologies (Dismantling by induction, Pyro system separation screw, Exothermic additives, etc.)
  - Demisable Joining Technologies (welding, epoxy, etc.)

→satellites use a large number of joints.

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

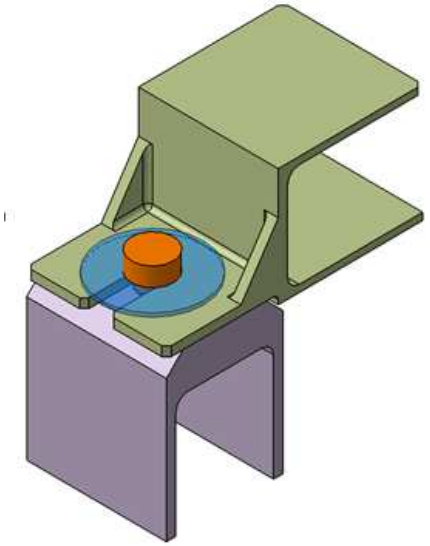


Schematic of Satellite Structure Typical Discrete Connections (Red Circled)

Demisable Joint

- The solution presented **Demisable Joint,** is based on a standard Aluminium joint in which two modifications are implemented:
  - one of the Al cleats is modified introducing an opening,
  - a washer, made of a material with low melting point, is adopted replacing standard Aluminium washer.

- Main advantages
  - Low cost
  - Low system level impact

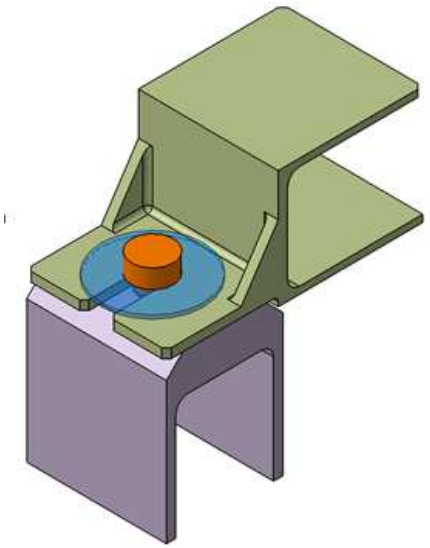


TASI Patent (patent N.TO2014A000998) by TAS-I as *Passive Device Designed to Facilitate Demise of a Space System During Re-entry into the Earth's Atmosphere*.

Demisable Joint

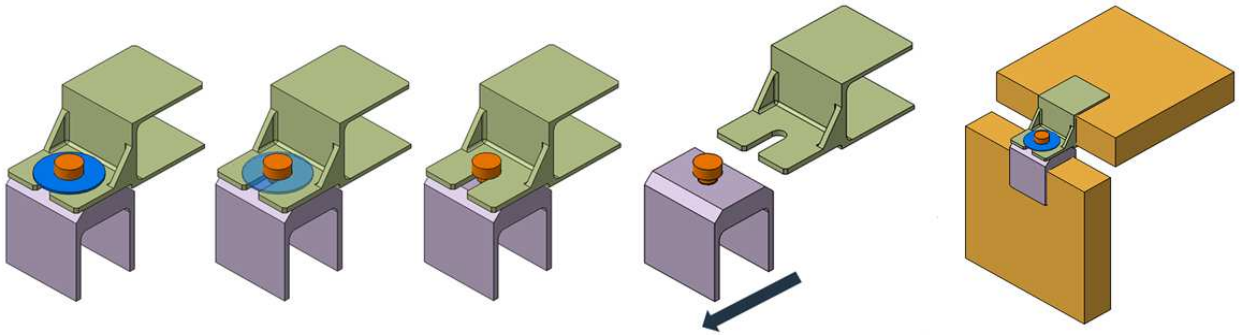
- The proposed Demisable Joint solution is a special joint design composed by an **innovative washer made of easy-demisable material** (i.e. having proper thermal properties, such as low melting point, low heat capacity, etc.) which can however accomplish its structural and functional role during the S/C operative life.

- Such joints will be applied to at least the key satellite structural joints, inducing the **detachment of the satellite external structure** with a consequent earlier exposure to the heat flux of massive internal equipment enhancing the disintegration of all satellite parts.



Demisable Joint

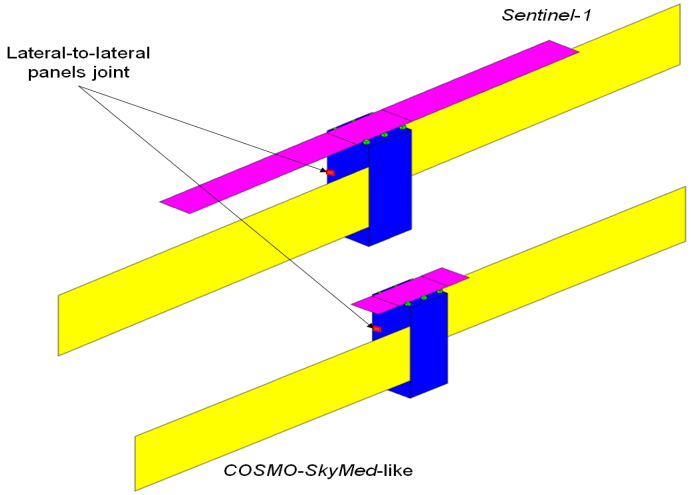
- During the operative life, the demisable washer (blue item) acts a usual washer in the joint assembly also composed by two cleats and a screw (orange item).
- During re-entry as consequence of the aerothermodynamic loads, the washer heats very fast, reaching the melting point earlier than the other 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 (near melting point the washer structural performances are very low)
- Once the washer has demised, the cleats can have a mutual shift, due to the proper hole in one of them (light-green item), eventually leading to the joint dismantlement.

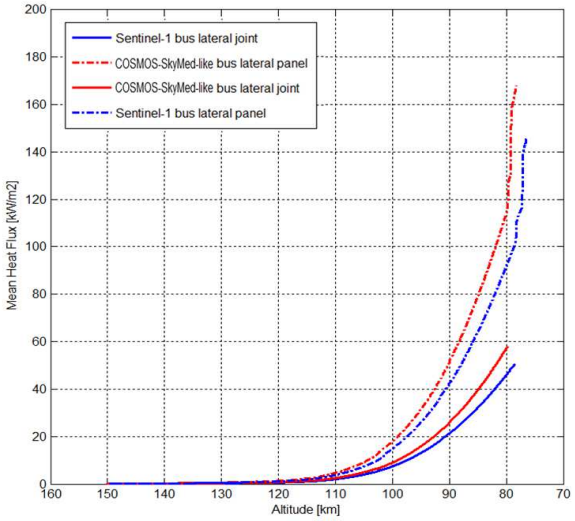


Demisable Joint based on a demisable washer – Baseline Design and Principle of Operation (left). Example of demisable joint implementation on lateral structural panel (right)

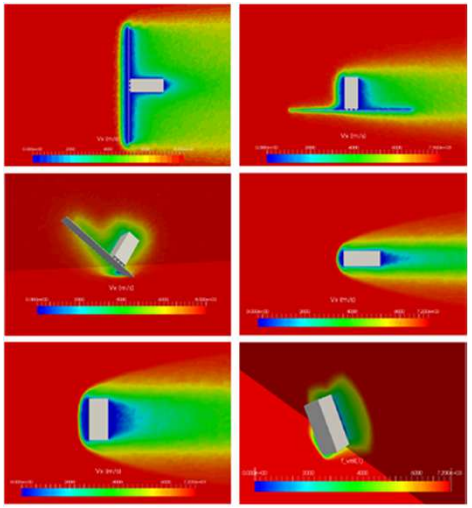
Re-entry conditions definitions

- In order to successfully test the demisable joint, the knowledge of the environmental conditions is essential.
- Needs of combining different tools to predict the re-entry environment



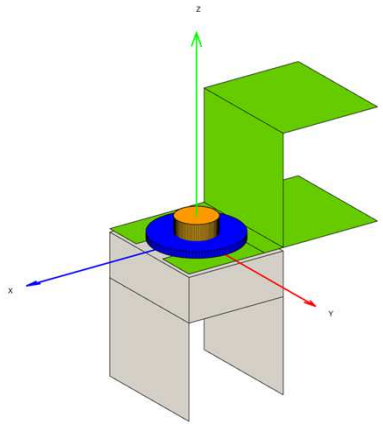


Sentinel-1 and COSMOS-SkyMed-like mean heat flux on lateral panels and lateral panel joints evaluated with TADAP

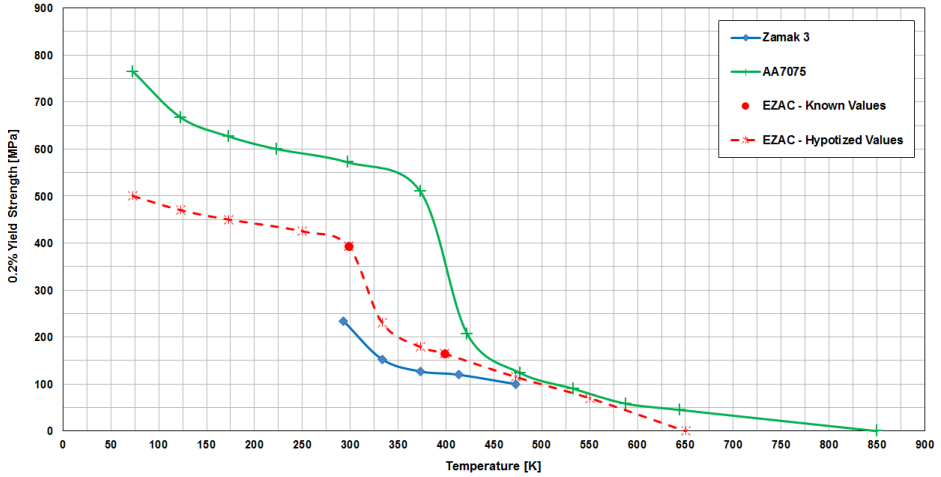


DSMC simulations performed in SPARTA (Stochastic PArallel Rarefied-gas Time-accurate Analyzer).Six configuration

Washer material selection



TADAP model of Demisable Joint



AA7075, EZAC and Zamak 3 yield strength vs temperature

Name	Composition	Density	Heat Capacity	Melting/ Activation Temperature	Melting Enthalpy	Emissivity Coefficient	Conductivity	Yield Strength	Heat of Demise
[-]	[%]	[kg/m^3]	[J/kg/K]	[K]	[J/kg]	[-]	[W/m/K]	[MPa]	[KJ]
EZAC™	Al 9.0-18.0 Cu 4.0-6.0	6600	460	670	120000	0.200	120.0	396	290

Demisability Test approach

Test approach

A test approach able to test the joint technology under representative re-entry condition is presented.
In order to cover the main aspects of the re-entry 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)

Since there are no facilities able to reproduce all these aspects together at the same time, an integrated approach to the testing:

- Plasma wind tunnel tests, (with the possibility of applying a static load to the joints)
- Tests on a static facility able to reproduce at the same time the temperature and mechanical loads profile