INVENT
25 YEARS

Novel Demisable Joints

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2021 Clean Space Industrial Days

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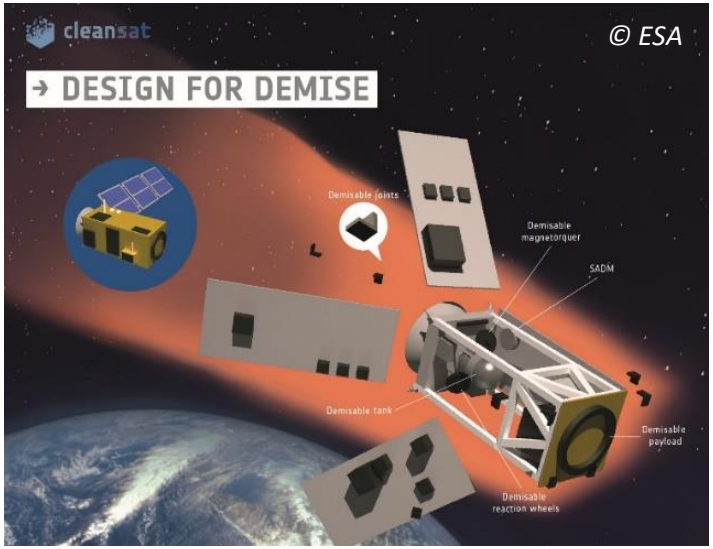
PASSION FOR COMPOSITES

How to improve satellite demisablity during re-entry?



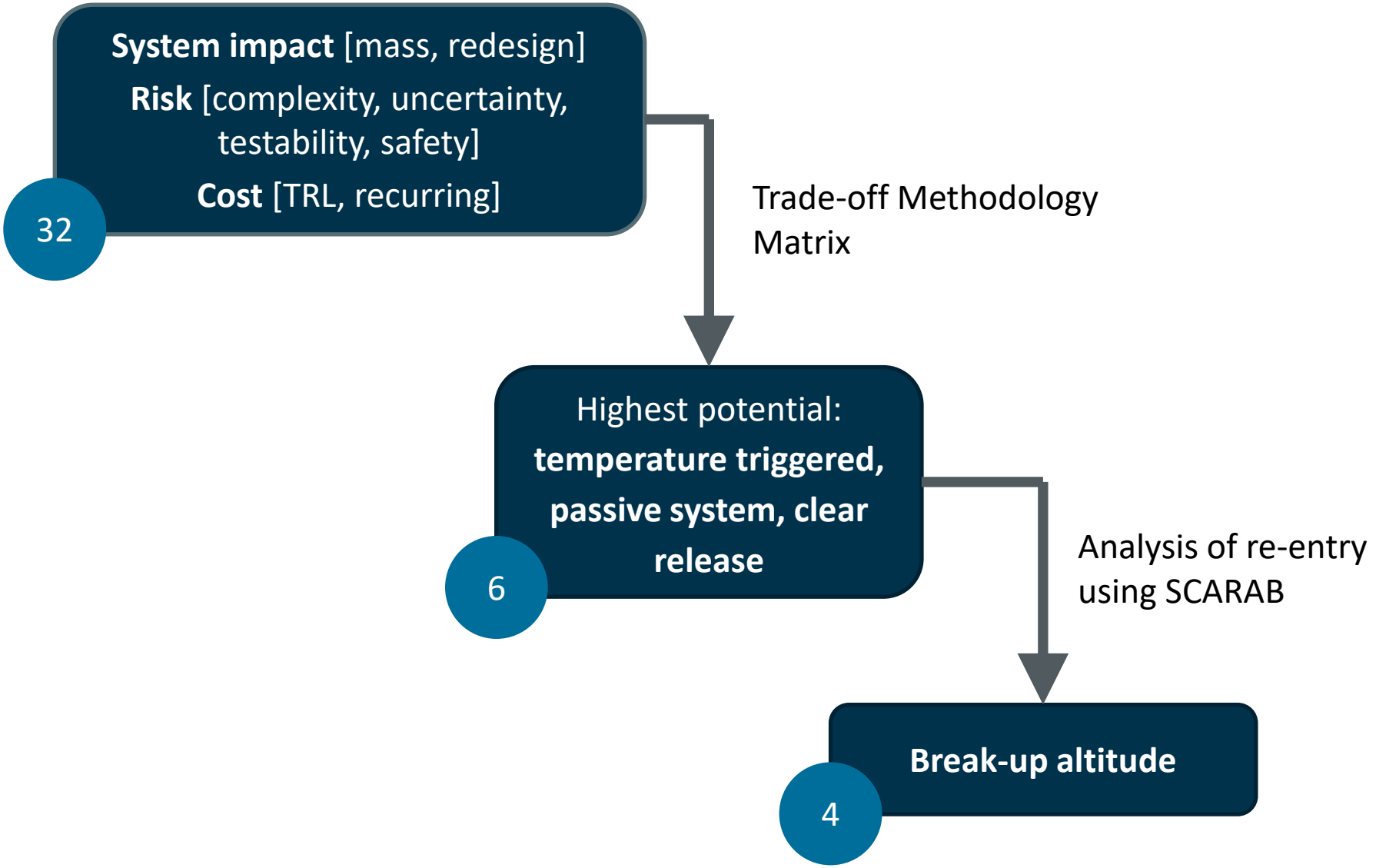
ESA funded study:

"Multi-Disciplinary Design and Breadboarding of Technologies for Early Break-up of Spacecraft During Re-entry"

Consortium: OHB (prime), AAC, Belstead, DLR, Fluid Gravity Engineering, INVENT

➔ **Improvement of S/C break-up and heat introduction to internal components by releasing external panels / modules**

Phase 1	→	**Phase 2**	→	**Phase 3**
Understanding state-of-the-art		Design of new concepts		Manufacturing and test of new concepts


System impact [mass, redesign]
Risk [complexity, uncertainty, testability, safety]
Cost [TRL, recurring]
32
Trade-off Methodology Matrix
Highest potential:
temperature triggered, passive system, clear release
6
Analysis of re-entry using SCARAB
Break-up altitude
4

Bonding joint

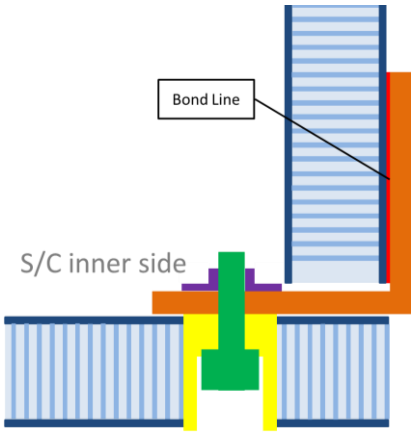
- No form fit
- External placement

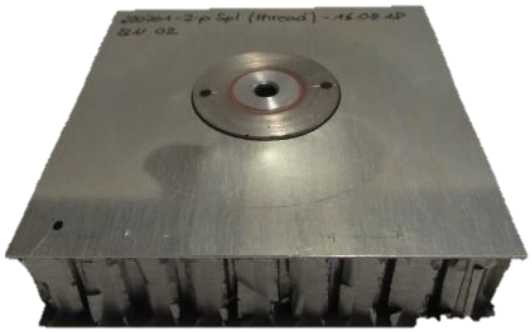
Demisable insert

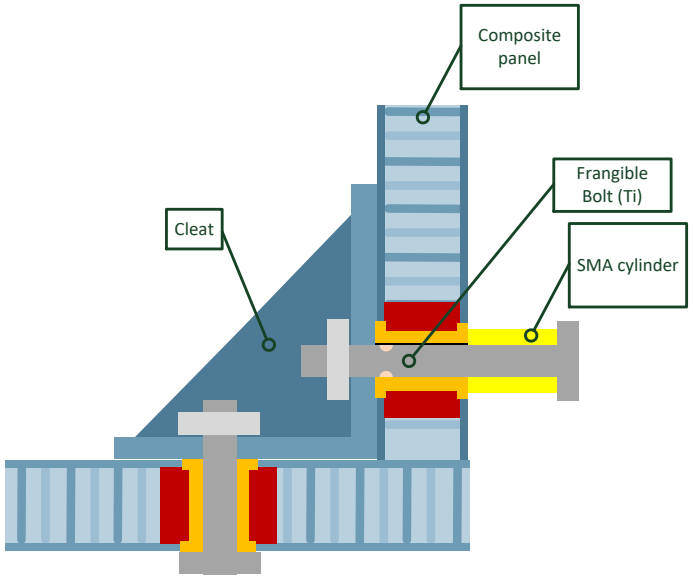
- Temperature sensitive insert
- Different insert designs
- Minimal re-design of S/C needed
- Minimal increase of mass

SMA bolts

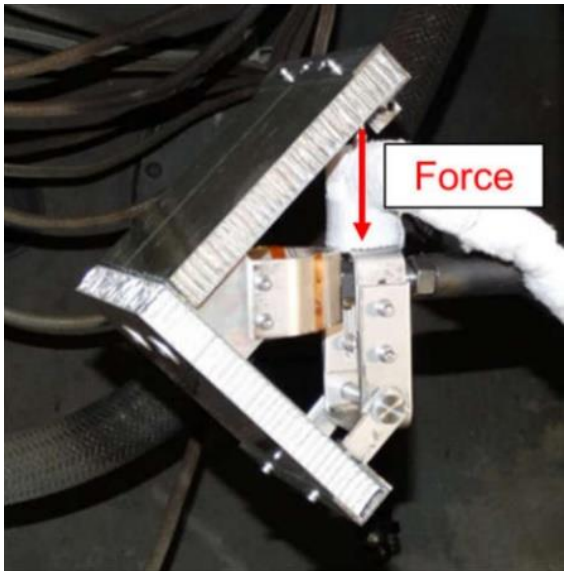
- Temperature sensitive bolt
- Placed externally
- Increase of cost & mass



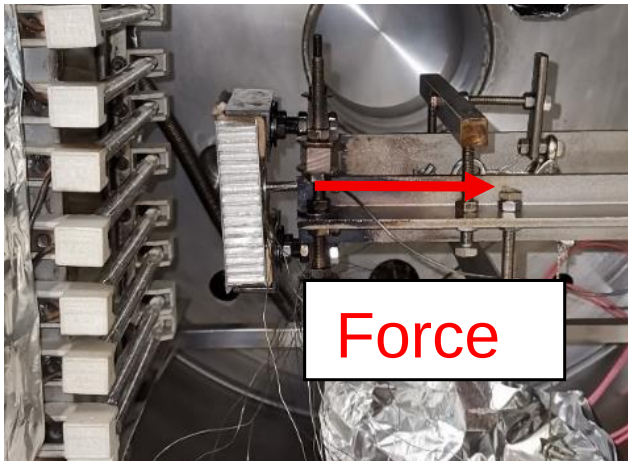




- **2-panel setup**
  - simplified representation of spacecraft corner connection
  - 45° angle of heating allows equal heat flux on both panels
- **1-panel setup**
  - focus on the insert region itself



DLRs L2K chamber; 2-panel setup

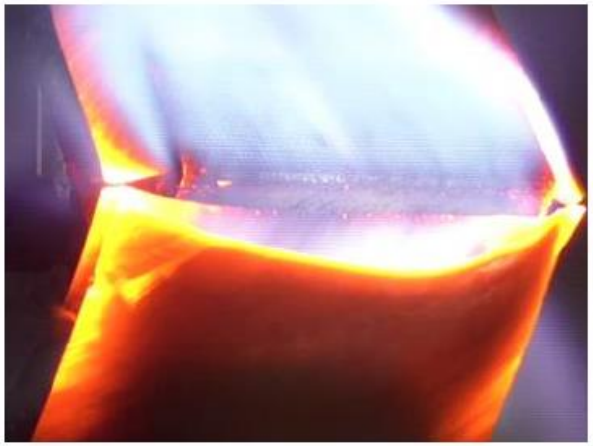


AAC's Re-entry Chamber; 1-panel setup

Re-entry Test Results - Bonded Cleats

- Very promising result for one flange bonded to outer panel side
- Failure of panel-panel connection either through:
  - cleat bondline failure
  - loss of sandwich panel integrity

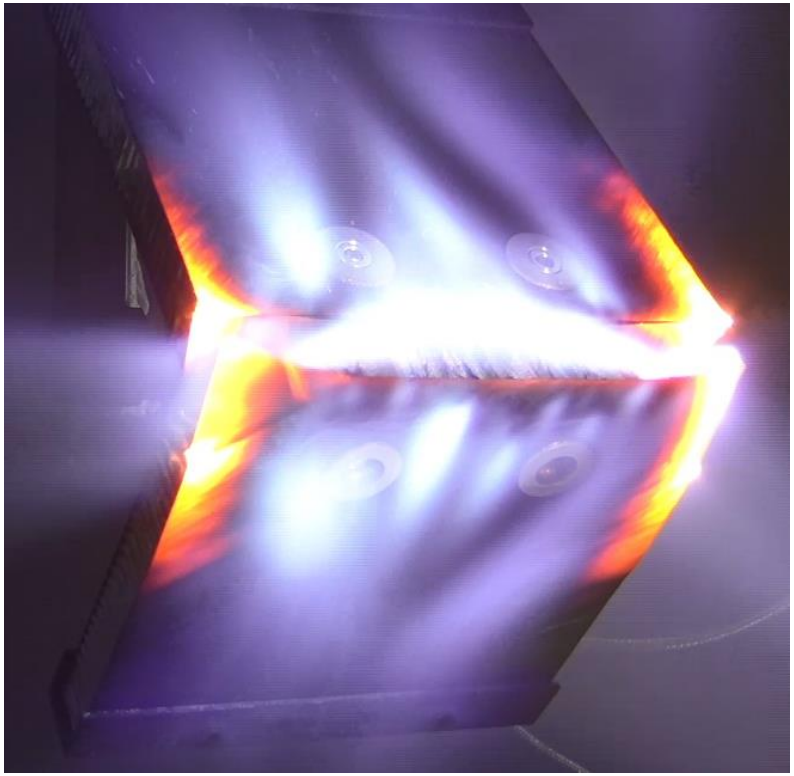
- In general, **limited demiseability improvement** seen
  - Detachment between 300°C - 400°C



Outer cleat sample setup during wind tunnel testing

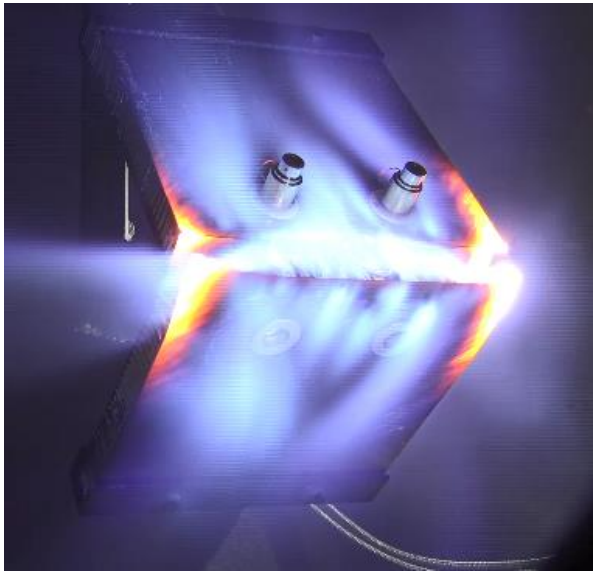
Outer cleat samples setup; delamiantion at cleat edges before bondline failed

- **Highly effective concept**:
  - Destruction of inserts within trajectory and constant heat flux
  - Consistent for the aluminium and CFRP faceskins
  - Clear release of the panels visible
  - Releases at approximately 140°C
  - Correlates to the prediction

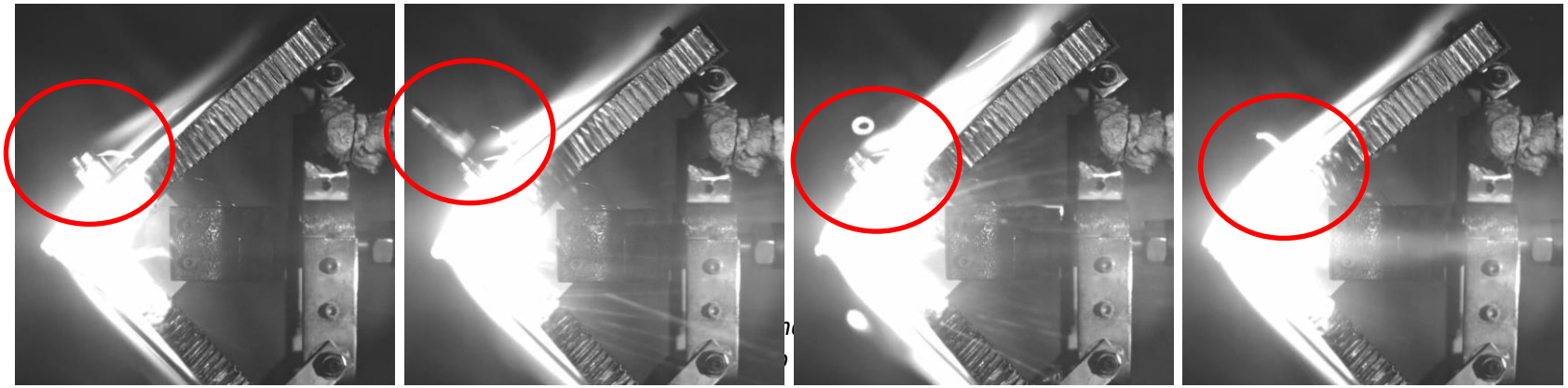


2-panel setups during wind tunnel testing

- SMA bolts mounted externally for best exposure
- **Highly effective concept**:
  - Clear release of the panels
  - Actuation between 170°C - 210°C
  - Correlates to the prediction
  - Triggered the fastest of all demise tests
- Trajectory heat flux not tested



2-panel setups during wind tunnel testing



Triggering of SMA cylinders

Re-entry results contributed to re-iteration of trade-off matrix:

- **Demisable insert**
  - demise behaviour reliable and earlier than expected
  - low overall system impact
  - recurring cost advantage to SMA bolt concept
- **Bonded cleat**
  - slight demise improvement
  - lowest mass impact
  - advantageous for internal cleats, as form fit is avoided
- **SMA bolt**
  - demise behaviour reliable and earlier than expected
  - high mass and system impact

- Understanding of demise processes greatly expanded
  - Some of the results are as expected
  - others deviate from the expectations

- Improvement of spacecraft demisability through:
  - **Appropriate utilisation** of numerous **demise technologies** ➔ Multi-faceted design approach
  - Most promising overall concept: **demisable insert**
    - Can be made applicable across the spacecraft
    - Low impact for spacecraft design

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THANK YOU FOR YOUR ATTENTION!

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