SpaceCraft Object Risk Evaluation Database (SCORED)

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Objectives

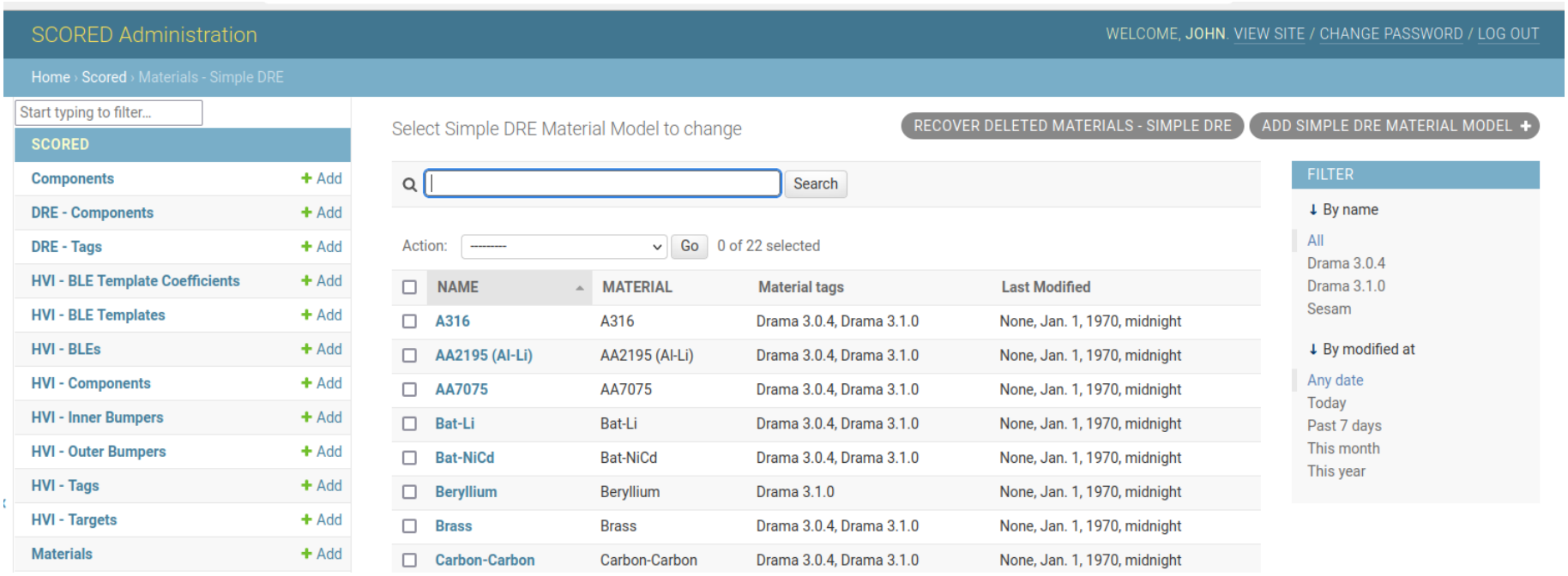
- Improvement of Space Debris Risk Methodologies
  - Database of recommended models
    - Material level, component level, uncertainties
    - High current dependence on modeller
- Destructive Re-entry Analyses
  - How to model components for ground casualty risk assessment?
  - Database contains recommended material models
  - Database now contains standard models for specific components
    - Reaction wheel model has been derived for DRAMA / SAMj
    - 1N Thruster & fill / drain valve models developed in this work
- Hypervelocity Impact Analyses
  - How to model the stack?
  - Database will contain standard models for specific components
    - Electronics box penetration
    - Harness (at a distance from panel)

Three Tracks

Software	Flexible Database Model Export Functionality
Destructive Re-entry	Materials Database Components Database
Hypervelocity Impact	Materials Database Components Database

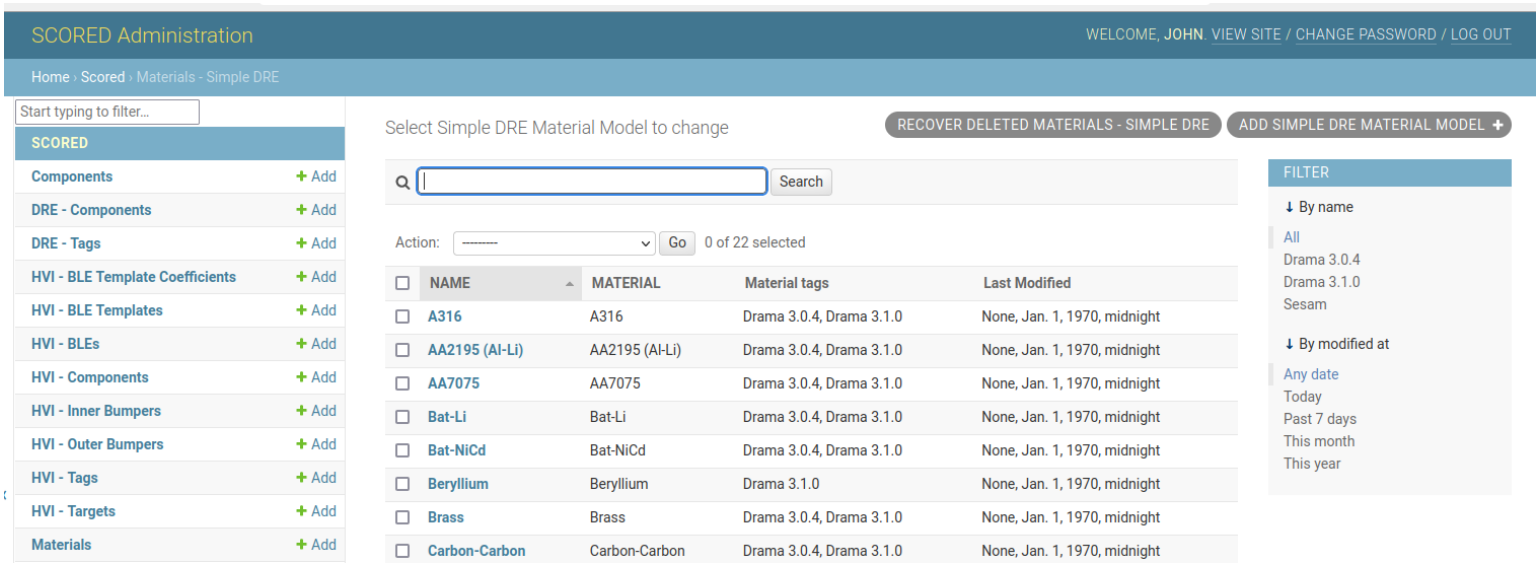
Software

- Single instance hosted by ESA
  - Models stored in Postgres database
  - Data maintenance performed using Django / Python web application



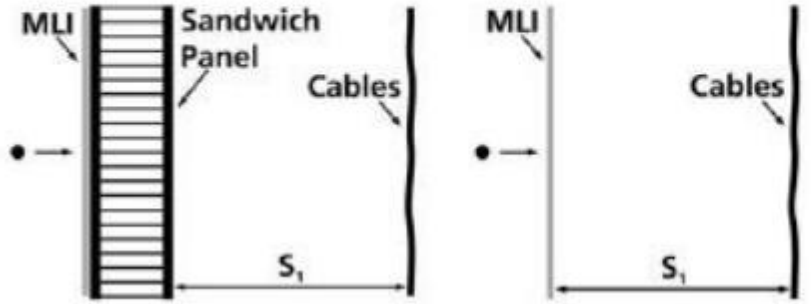
Software

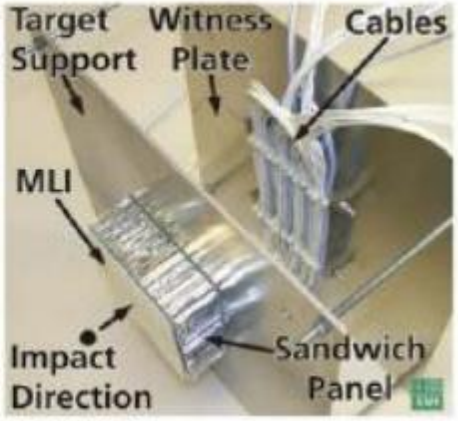
- Data exports for current clients
  - DRAMA/SESAM material and component databases
  - DRAMA/MIDAS BLE and component definitions
- Potential future 3rd party application connectivity using RESTful API



Hypervelocity Impact

- HVI effect is based on Ballistic Limit Equations (BLEs)
  - Range of existing BLEs
  - Selection is important
  - Database output will guide the user on which BLE
    - Component and shield parameter ranges (e.g. density, thickness, spacing) identify applicable geometry
    - Failure criterion (e.g. spallation, penetration) define BLE
- Model for electrical harness
  - Data exists on harness impact at a distance from a wall
  - BLEs re-derived for use in database





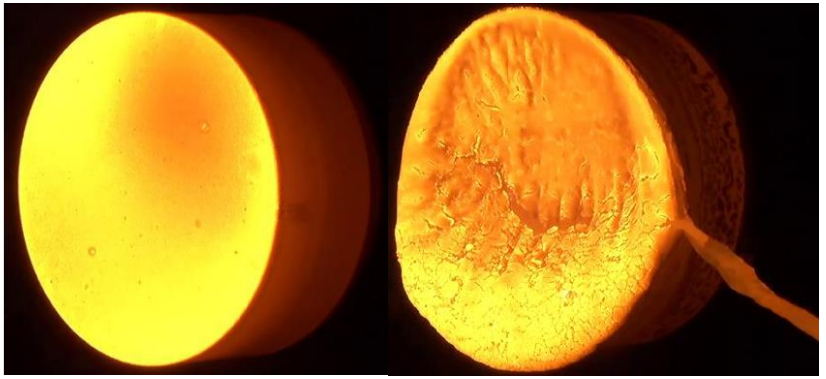
Hypervelocity Impact – initial data set

- 22 material models including
  - Aluminium, aluminium alloy, steel, CFRP, titanium
- Component models
  - Electrical harness protected by aluminium or CFRP sandwich panel
  - Unprotected electronics box
  - Electronics box protected by aluminium plate
  - Electronics box aluminium or CFRP sandwich panel
  - Unprotected fused silica glass (optical instrument)
  - Unprotected titanium tank
- BLEs
  - All existing MIDAS BLE definitions
  - Specific BLE definitions for each component / protection / failure criterion combination

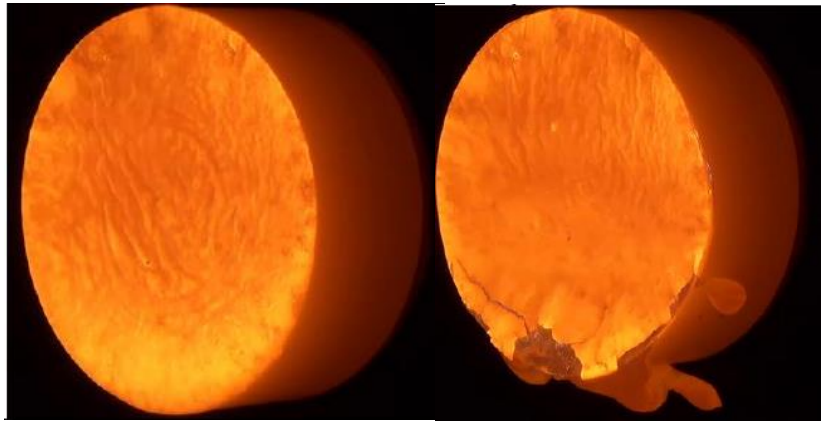
Destructive Re-entry

- Development of Thruster Model
  - Scrap 1N thrusters obtained from ArianeGroup
  - Plasma wind tunnel test campaign
    - Material testing (Haynes 25, Inconel 718)
    - Parts testing
    - Mock-up nozzle testing to understand scaling
    - Complete thruster testing
- Two test campaigns
  - Parts tested in L2K, complete thrusters in L3K

Destructive Re-entry



- Haynes 25
  - Does not melt at melt temperature
    - Surface >200^{0}C above
  - Very strong oxide layer
    - Insulates material, holds liquid inside
    - Had to go to maximum power in L2K to release melt
      - Much higher than expected
    - Melt model is not appropriate – proxy model required
    - Reasonably low catalycity material; very high emissivity (0.95)
- Inconel 718
  - Has strong oxide layer
  - Does melt when it is supposed to
    - Still high temperature
  - Existing models are reasonable
  - Emissivity is high (0.9)

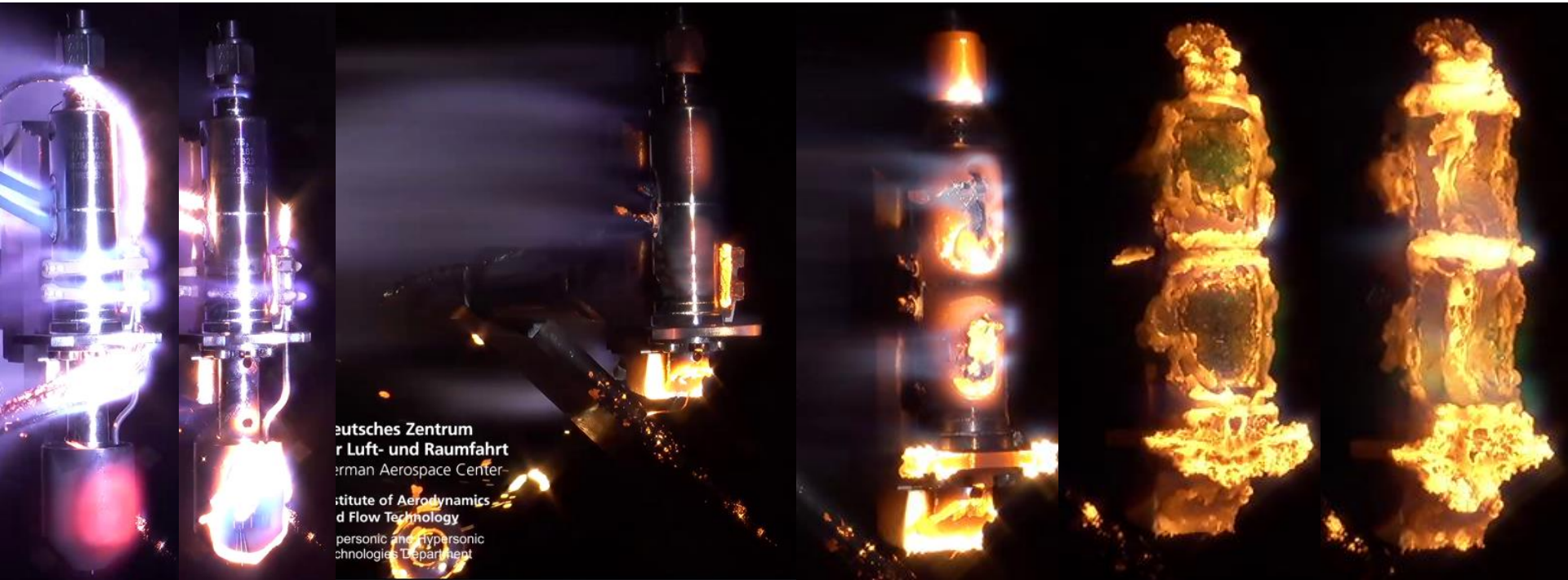


Destructive Re-entry – Thruster Parts

- Titanium tubing
  - Small radius – fast melt
  - Not major risk
- Haynes 25 parts
  - Different behaviour for thin and thick material
  - Thin material tears at melt temperature
  - Thick material has thick protective oxide
  - Different models required
- Very low demisability

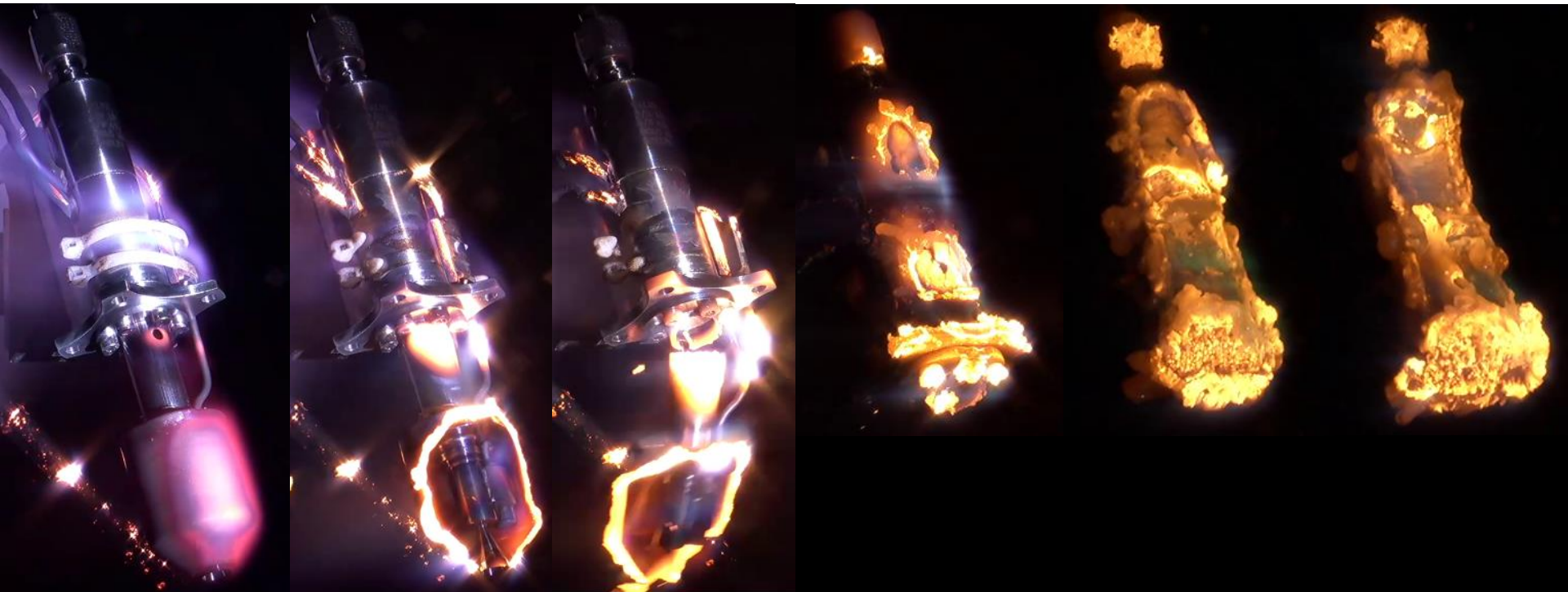
Complete Thruster Tests

- Full Thruster (90^0)
  - Cabling shears / fast melt of heatshield
  - Fragmentation of lower nozzle
  - Significant delay in melting of large inlet part due to outgassing
  - Melt starts up again once outgassing stops
- Demise slower than part tests
  - Slower than stepped approach – driven by outgassing



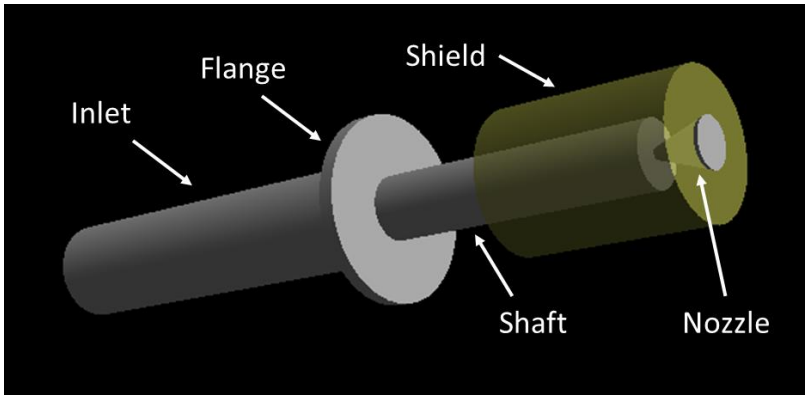
Complete Thruster Tests

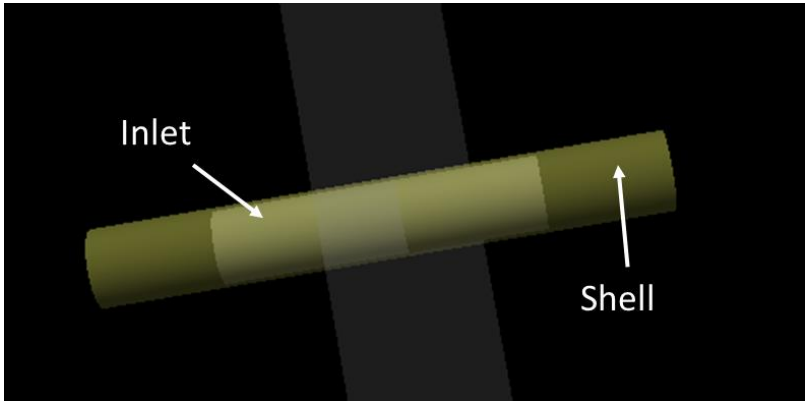
- Full Thruster (60^0)
  - Early failure of lower half nozzle consistent with other tests
  - Initial opening of large inlet part
  - Significant delay for outgassing
  - Continuing demise once outgassing stops
- Thruster is less demisable than assessed in L2K



1N Thruster Model Construction

- Two models constructed based on Ariane component
  - 5 object connected model suitable for complex tools
  - Simplified 2 component parent-child model for DRAMA
  - Both models composed of a mixture of Haynes 25 “thin” and “thick” materials
- Complex model designed to capture test data
- Extrapolated to flight
- Evaluate simple model statistically using PADRE with both DRAMA and SAMj
- Both models added to database





Destructive Re-entry – initial data set

- Material models
  - All existing DRAMA models
  - All existing ESTIMATE material properties
  - Haynes 25, Hiperco
- Component models
  - All existing DRAMA models
  - SCORED 1N monopropellant thruster
  - Simple layered magnetorquer
  - Generic demisable SADM
  - Generic fill / drain valve

- Preliminary component models (not included)
  - Fibre optic gyroscope
  - 10N bipropellant thruster

Conclusions

- Spacecraft Object Risk Evaluation Database
  - Hypervelocity impact
  - Destructive re-entry
- Database
  - Based on Django / Python
- Hypervelocity Impact
  - Models for electronics boxes
  - New models for harness
- Destructive Re-entry
  - Existing material models
  - Existing component models derived from test data
  - New model developed for thruster
    - New test-validated material models for Haynes 25 and Inconel 718
- Activity will Complete in 2023; Database Availability TBD