Belstead

SARA Glass and Ablative Materials and Other Modelling Enhancements

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Agenda

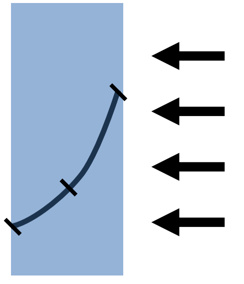
- Glass SBI materials
- Ablative SBI materials
- Mass loss child release criterion
- Rescheduling remaining parent mass

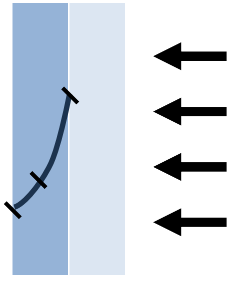
Glass SBI Model

- New glass material model
  - Output of COPPER activity (ESA contract #4000137639/22/NL/GLC)
  - Uses Simple Balance Integral (SBI) approach
- 5 additional glass models added to materials.xml
  - Borosilicate – Generic glass used for many science applications
  - Fused silica - High performance, low demisability glass (should be used for lenses if specific glass type is not known)
  - Soda lime glass - Low performance standard glass
  - Zerodur - Specific Schott glass-ceramic material
  - GFRP - Synthetic model of a GFRP electronics card (should be used in conjunction with an aluminium casing in preference to drama-El-Mat)

SBI Material Models

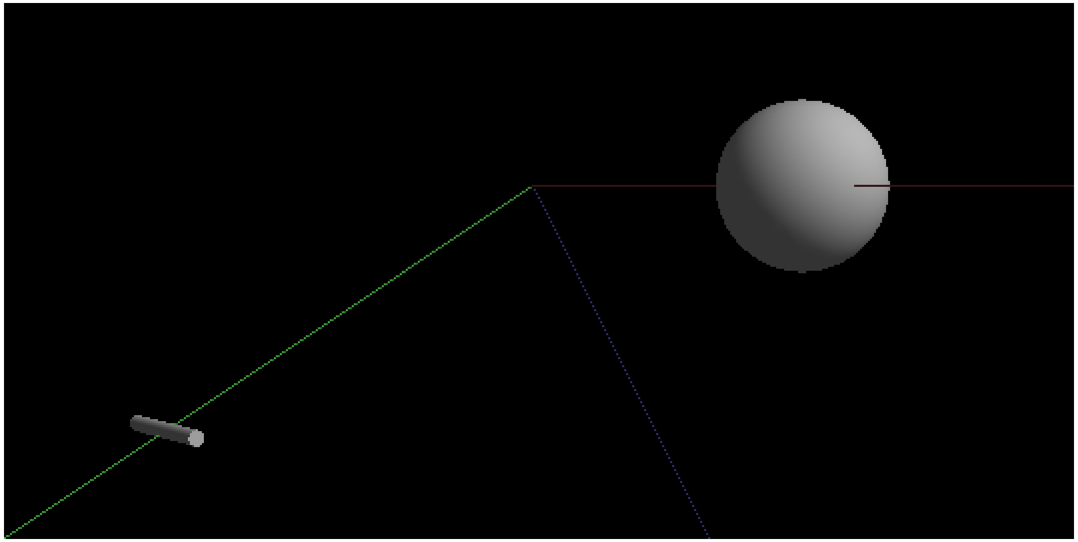
- Based on Heat Balance Integral approach
- Predict temperature profile in depth - More refined than isothermal bulk heated metal models (AA7075)
- 0D - Better performance than 1D layered models (DRAMA CFRP)
- Approach
  - Bulk heat object
  - Evaluate surface temperature using energy balance
  - Apply a quadratic temperature profile through surface and bulk temperatures to derive back face temperature
  - Remove material from front face using demise algorithm
    - Viscosity based for glasses
    - Pyrolysis based for ablative materials
  - Adjust front face and bulk temperature for lost hot material
  - Adjust back face temperature given new bulk temperature



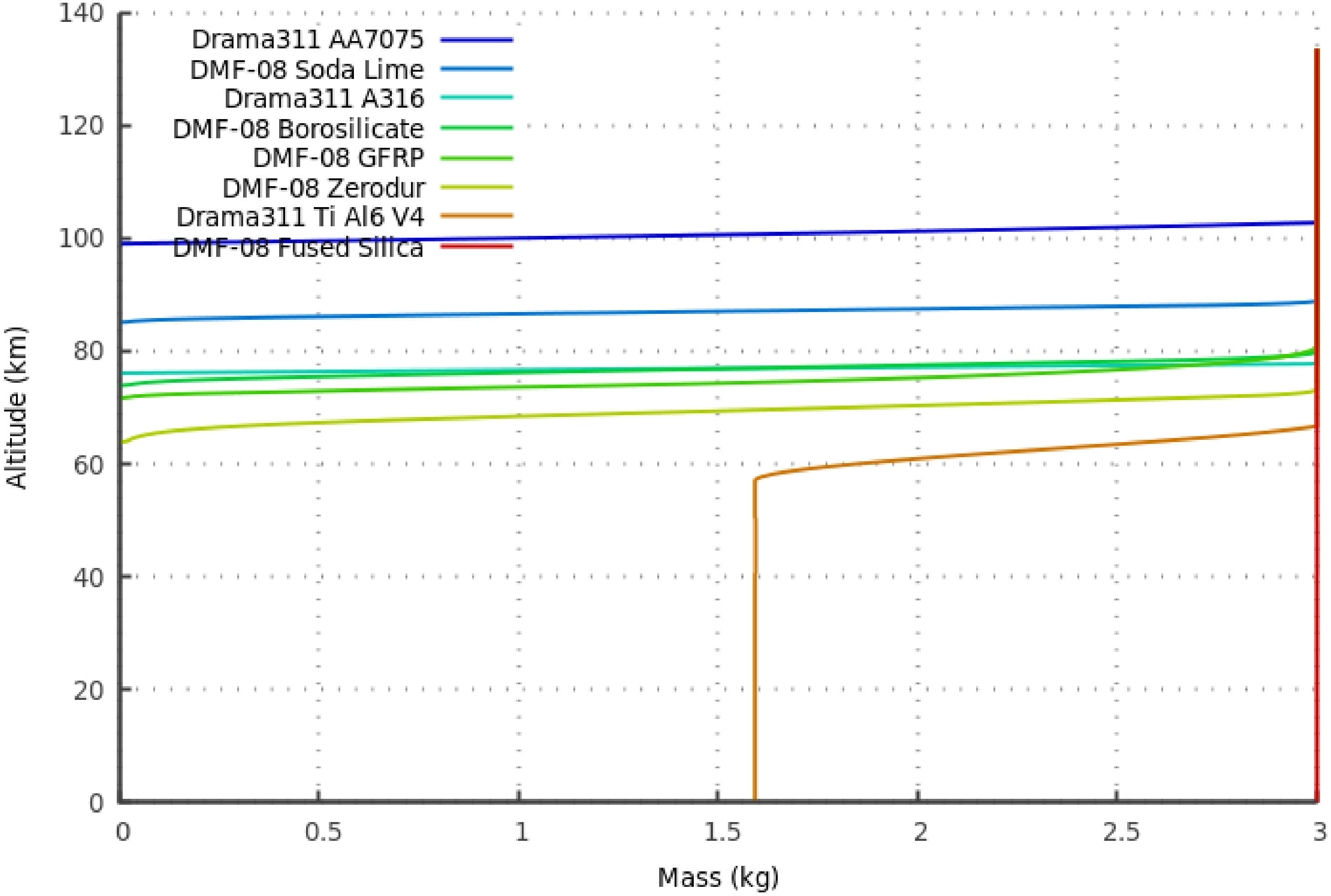


Glass SBI Model

- Material response / mass loss based on viscosity model
  - Vogel-Fulcher-Tammann (VFT) relationship $\log(\eta) = A + \frac{B}{T - T_0}$
  - Must be characterised for each glass material
- Performance
  - 3kg, 1000x100x6mm, 40kg/m^2 rod connected to 100kg, 950mm, 150kg/m^2 undemisable sphere)



Glass SBI Model - Performance

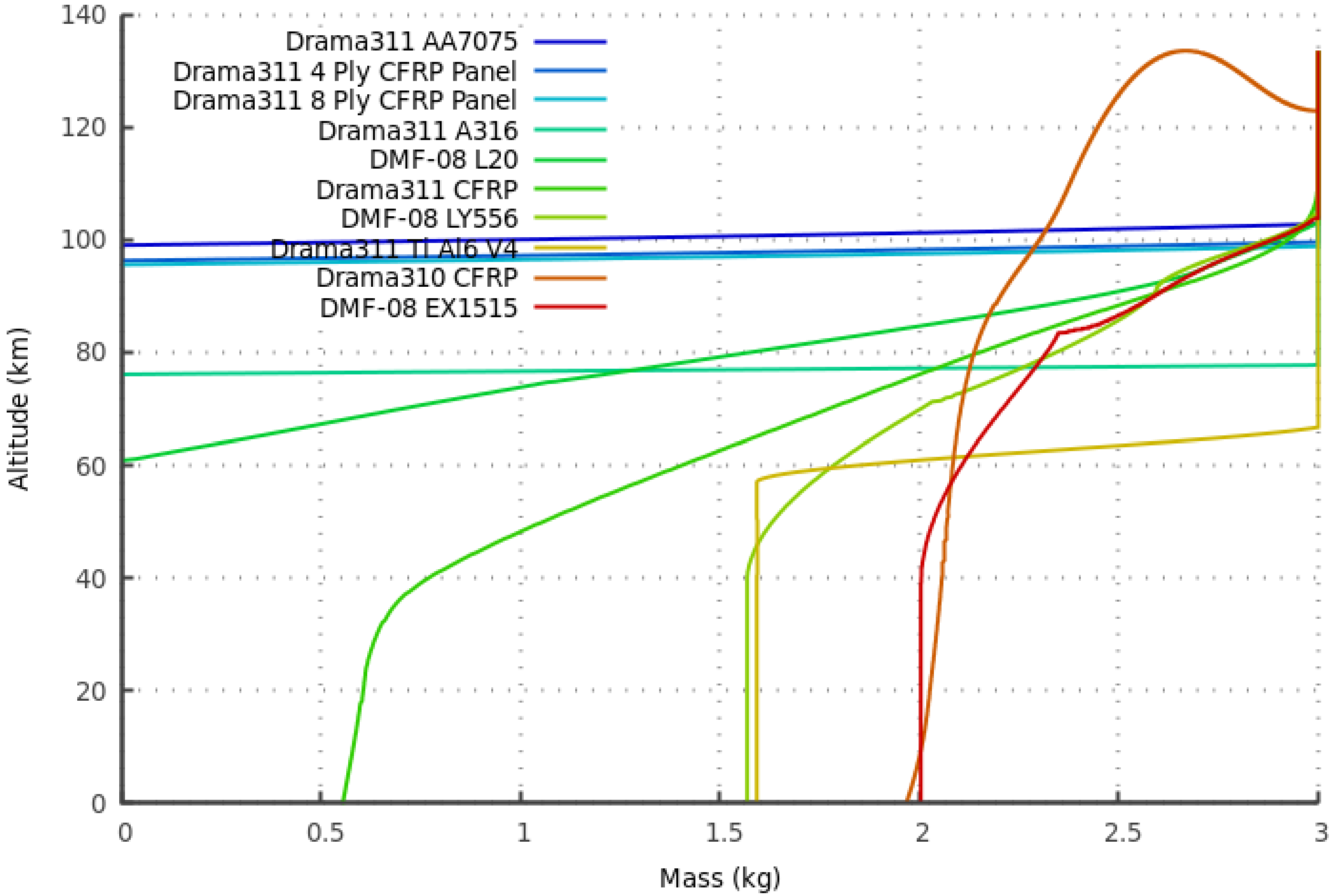


Ablative SBI Model

- New ablative material model
  - Output of COMP2DEM activity (ESA contract #4000125192/18/NL/LvH)
  - Uses same approach as glasses, but with composite material response
    - Pyrolysis of the matrix with blowing
    - Recession of fibres
    - Must be characterised for each material
- Demisability is driven by matrix char yield
- 3 additional CFRP models added to materials.xml
  - LY556 – Baseline monolithic CFRP with an LY556 matrix
  - L20 - High demisability monolithic CFRP with an L20 matrix (use must be justified)
  - EX1515 – Low demisability monolithic CFRP with an EX1515 matrix (should be used for CFRPs with cyanate ester matrices)

Ablative SBI Model - Performance

- 3kg, 1000x100x6mm, 40kg/m^2 rod tethered to 100kg, 950mm, 150kg/m^2 undemisable sphere)



Child Object Mass Loss Release Criterion

- Demise based component fragmentation was limited
  - Full demise – no criterion set, conservative
  - Temperature-based - typically onset of demise (melt temperature), optimistic
- Neither option is realistic
- Addition of new proportion of mass lost criterion (0-1)
  - 0 = fragmentation when no mass lost
  - 1 = fragmentation when all mass demised
- Values suggested by wind tunnel tests
  - Aluminium – 0.5-0.9, typically 0.7
  - Steel – 0.3-0.7, typically 0.5
  - Other materials – No test results, assume full demise and don't use criteria unless justified

Reschedule Remaining Parent Mass

- Any remaining mass is lost when a child release criterion is triggered
  - Implies catastrophic breakup and no remaining fragments generate casualty risk
  - Optimistic when using altitude, temperature and mass loss criteria
  - Means of losing mass from risk assessment
- Change to permit remaining parent mass to continue to be simulated
  - No change in geometry
  - Should be the default, unless catastrophic assumption is justified
  - More important with the inclusion of the mass loss criterion

Status / Release Timing

- Implementation of all enhancements complete and released to ESA
- Currently undergoing ESA QA
- Due for release in DRAMA / DMF v4.1 - summer 2025