



Does the Presence of MLI Increase Ground Risk From Re- entry?

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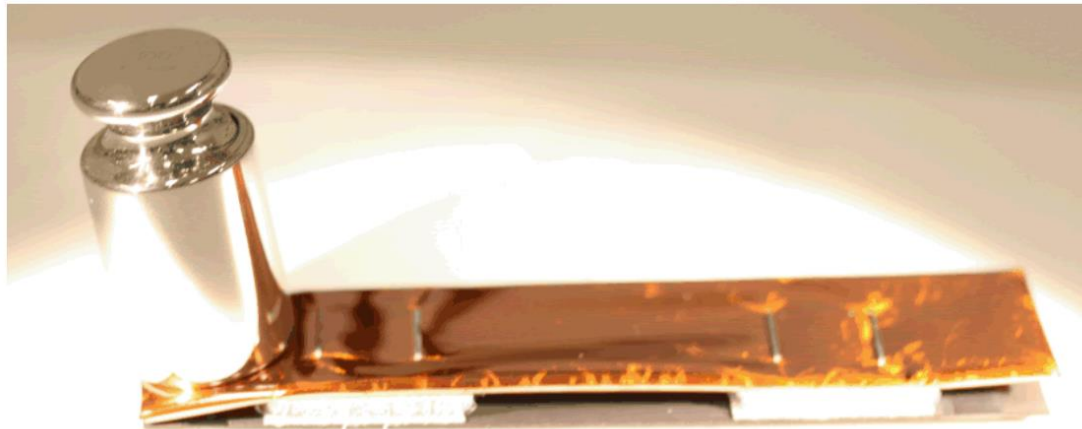
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MLI Impact

- Does MLI have an impact on demisability
 - Is it still present?
 - Is it damaged and brittle?
 - What reduction in heat input can result if it is there?
- Two steps
 - Atomic oxygen testing
 - Potential high fluence in final days of re-entry
 - Effect on MLI, fastenings
 - What is material state at re-entry threshold?
 - Further joint testing
 - Impact of presence of MLI
 - What is impact on joint/sandwich failure?

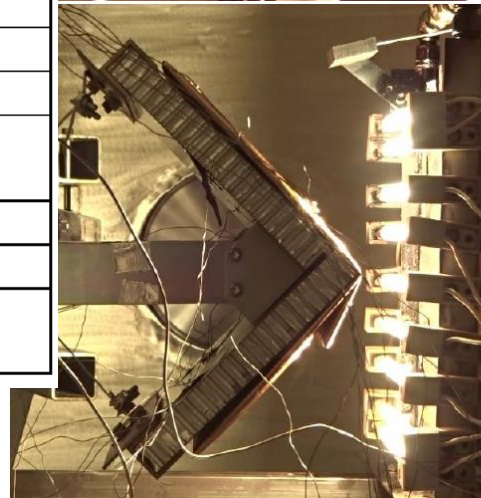
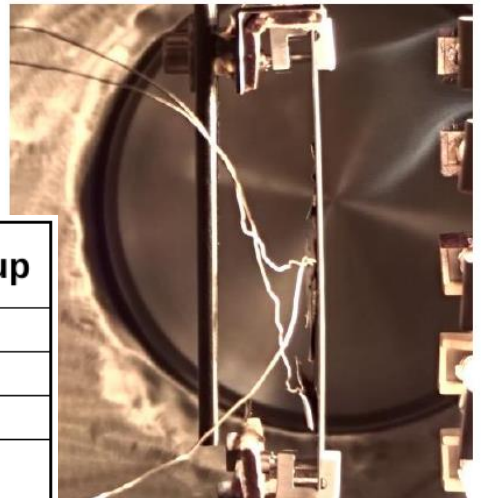
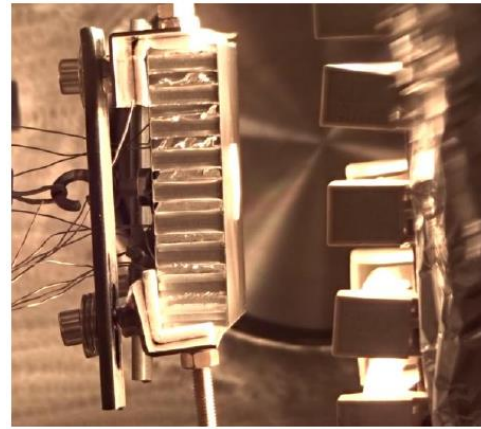
ATOX Testing

- Tests Performed at ESTEC Facility
 - Fluence consistent with 25 years re-entry
 - No significant degradation or embrittlement
- MLI is Undamaged
 - Virgin MLI provides reasonable test samples



Static Testing

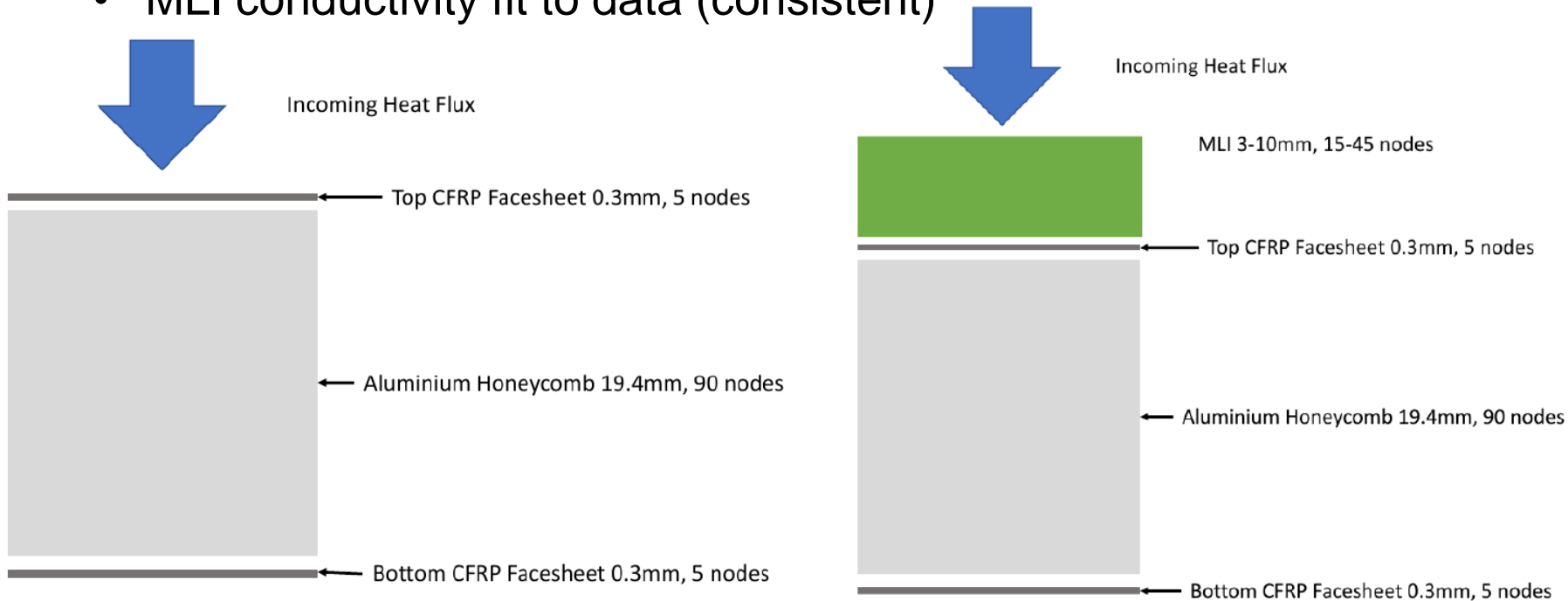
- Three test types
 - Single panel
 - Stripes (ATOX tested)
 - Two-panel



ID	Load (N)	MLI	Aged?	MLI Fixation	Insert Type	Panel Setup
1	20	None	N/A	N/A	Spool	Single
2	20	Baseline	Unaged	Stand-offs	Spool	Single
3	20	Baseline	Unaged	Velcro	Spool	Single
4	None	Nominal	ATOX exposed Unaged	Stand-offs	N/A	Stripe
5	20	Kapton Black	Unaged	Stand-offs	Spool	Single
6	20	Kapton Black	Unaged	Velcro	Spool	80x80
7	None	Kapton Black	ATOX exposed Unaged	Velcro	N/A	Stripe
8	20	Aktar Black	Unaged	Stand-offs	Spool	80x80
9	20	Baseline	Unaged	Stand-offs	Demisable	80x80
10	20	Baseline	Unaged	Stand-offs	2 x Spool 2 x Standard	2 Panels 160x160

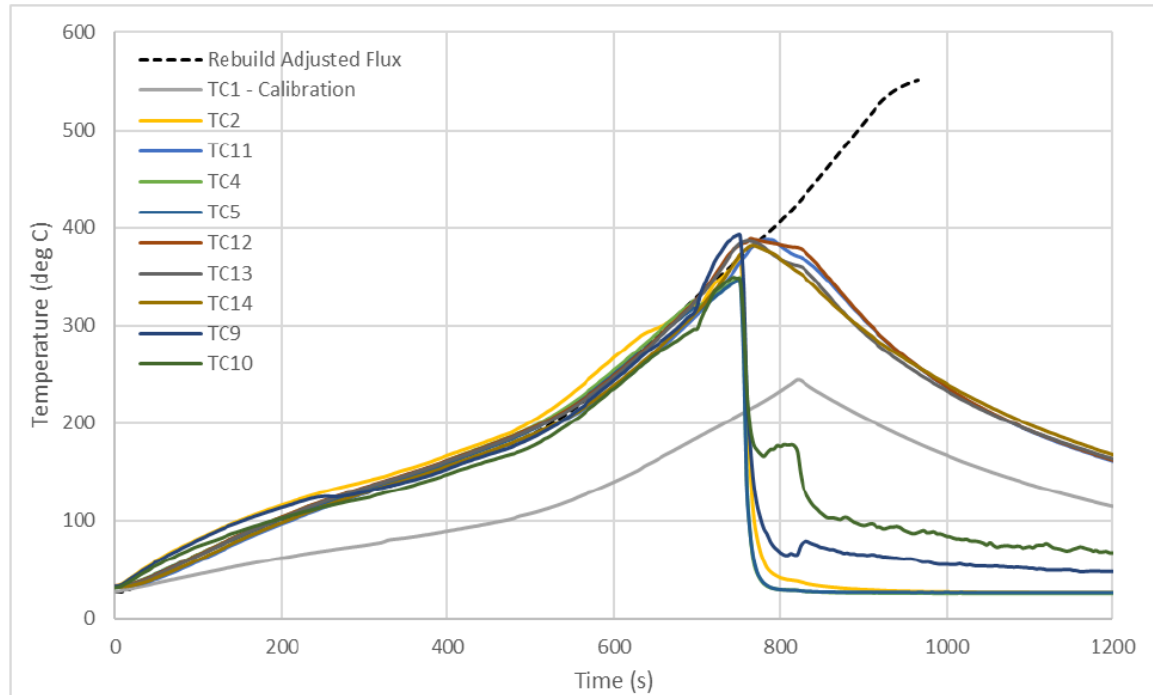
SAMj Model

- 1D layup used
 - Different layup with MLI present
 - MLI conductivity fit to data (consistent)



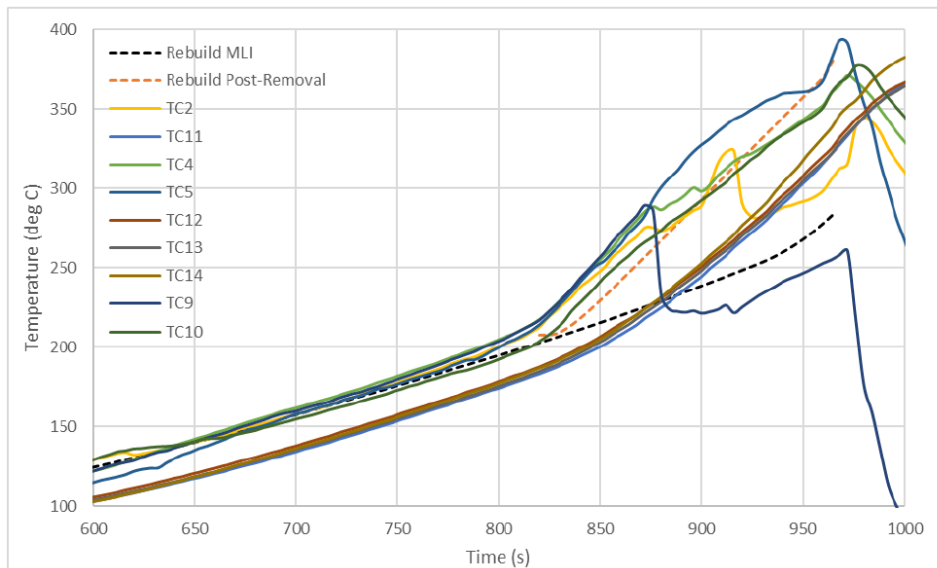
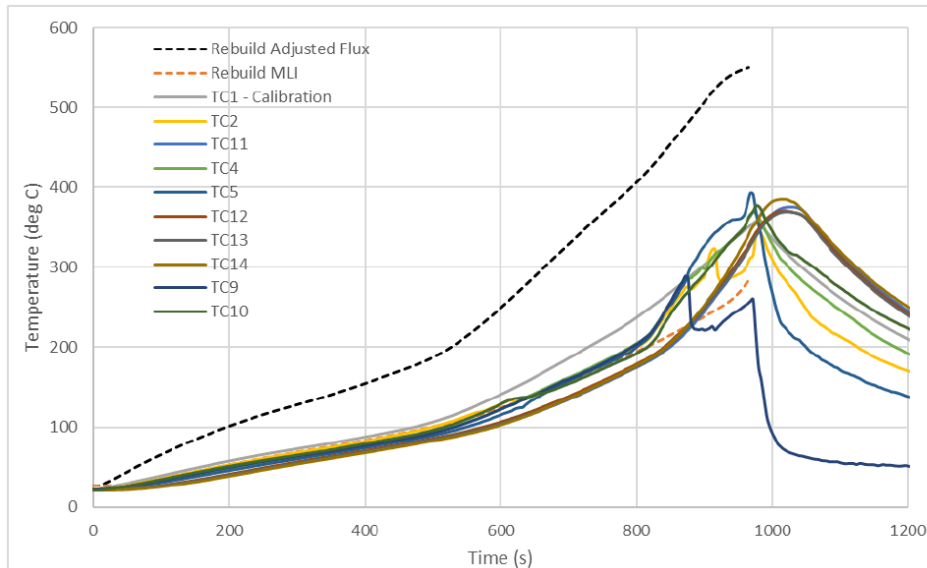
No MLI

- Control Test
 - Good rebuild
 - Close to isothermal
 - Front facesheet off
 - Spare sample
 - Consistent



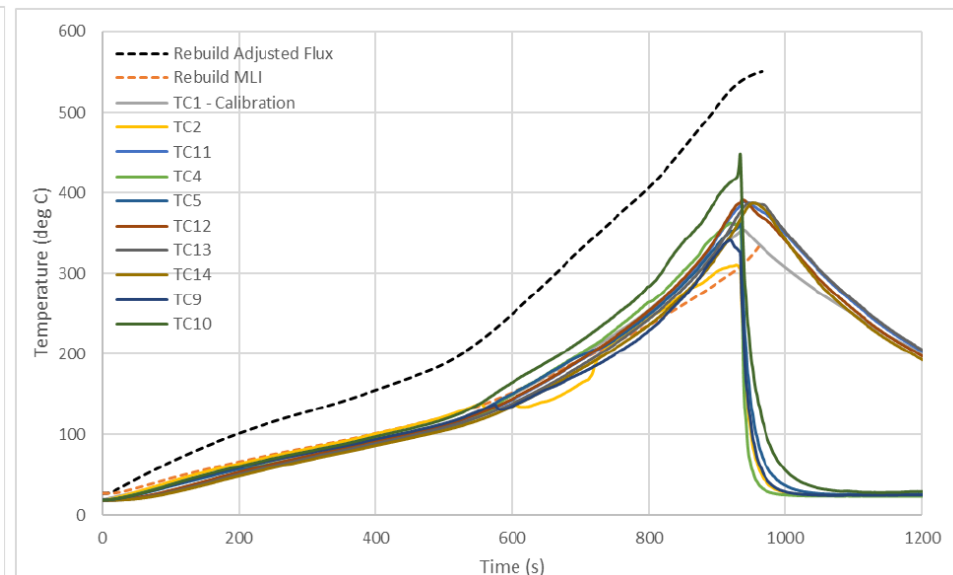
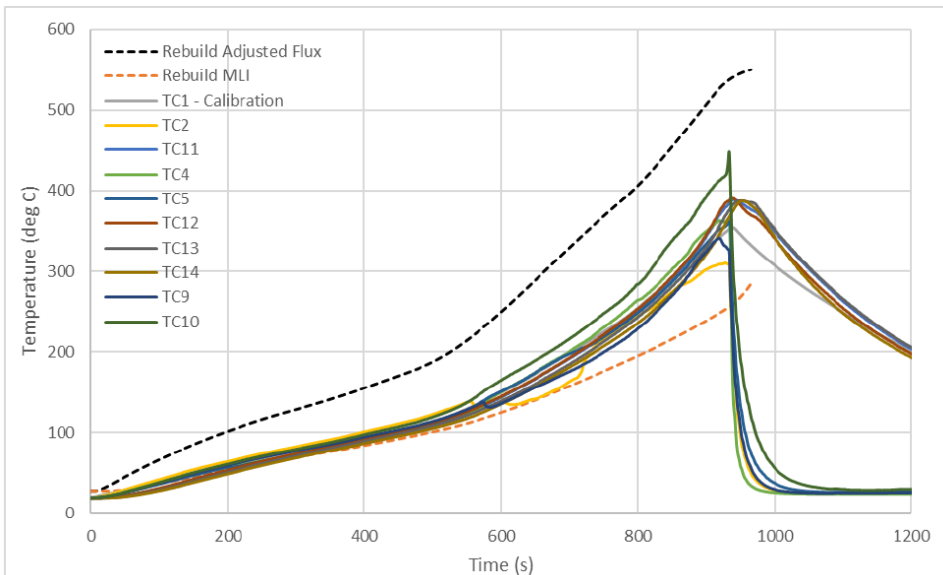
Baseline MLI / Standoffs

- MLI Test
 - Clear reduction in heating from MLI presence
 - Warping of MLI at 200°C, increased flux
 - Front sheet removal at 350°C, panel collapse soon after
 - Heating captured by model after panel release



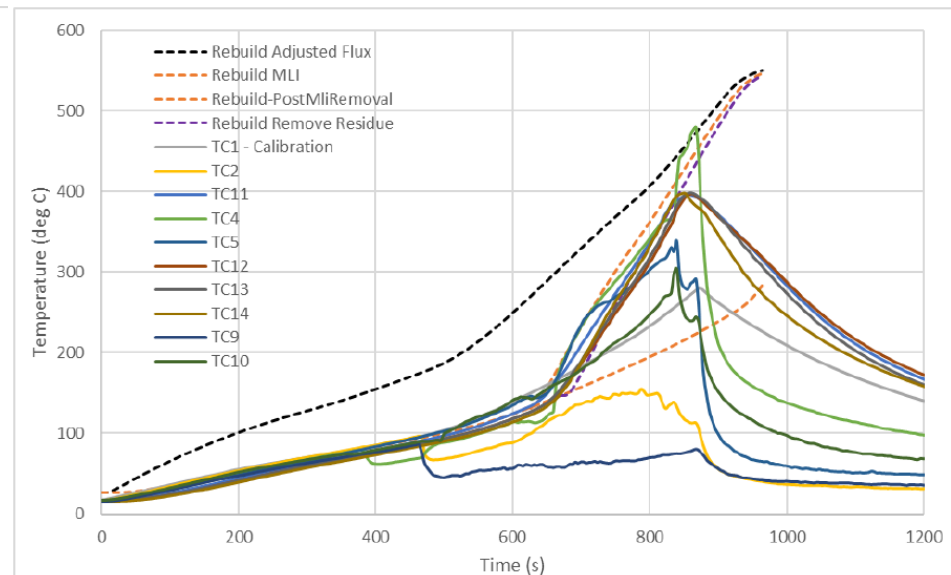
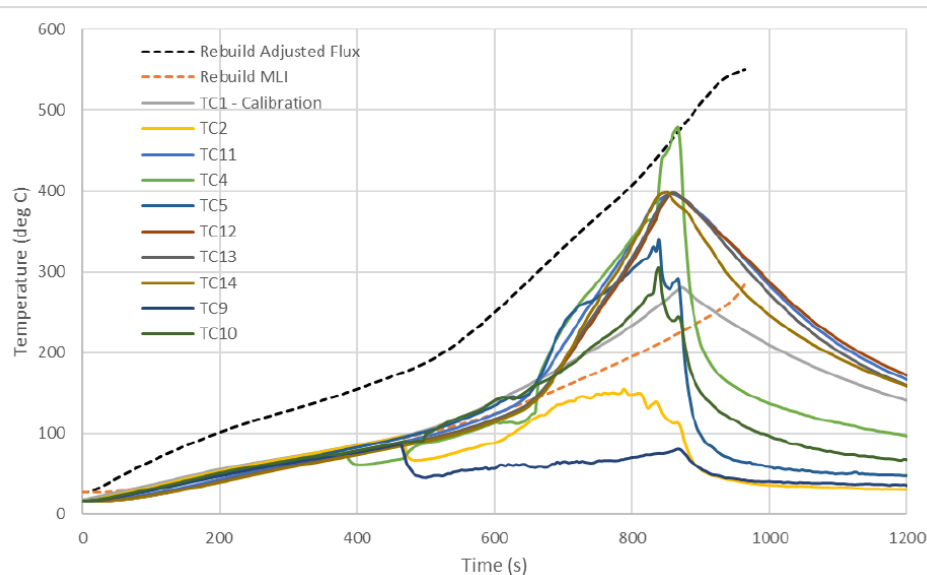
MLI / Standoffs

- Alternative MLI Materials (Kapton Black)
 - Slightly less insulation effect
 - Baseline model (left), adjusted model (right)
 - Same temperature thresholds for warping, frontsheet release
 - Standoffs are not removed – released with frontsheet



MLI / Velcro

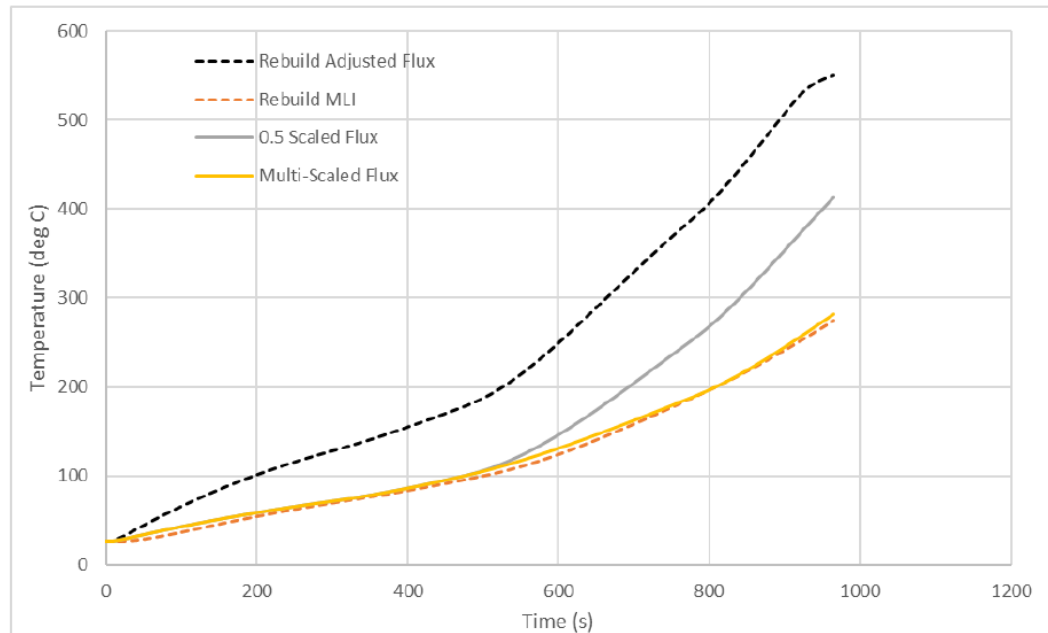
- Baseline MLI
 - Same MLI insulation model – consistent behaviour
 - Much earlier release of MLI, Velcro melt $<150^{\circ}\text{C}$
 - CFRP Frontsheet remains in place, removed at 350°C
 - Again, model captures heat rise after removal



Extrapolation to Flight

- Proxy Scale for Input Heat Flux

- Models for MLI removal
- Velcro
 - Fail at 150°C
- Standoffs
 - Warping at 200°C
 - Increased flux
 - Removal at 350°C



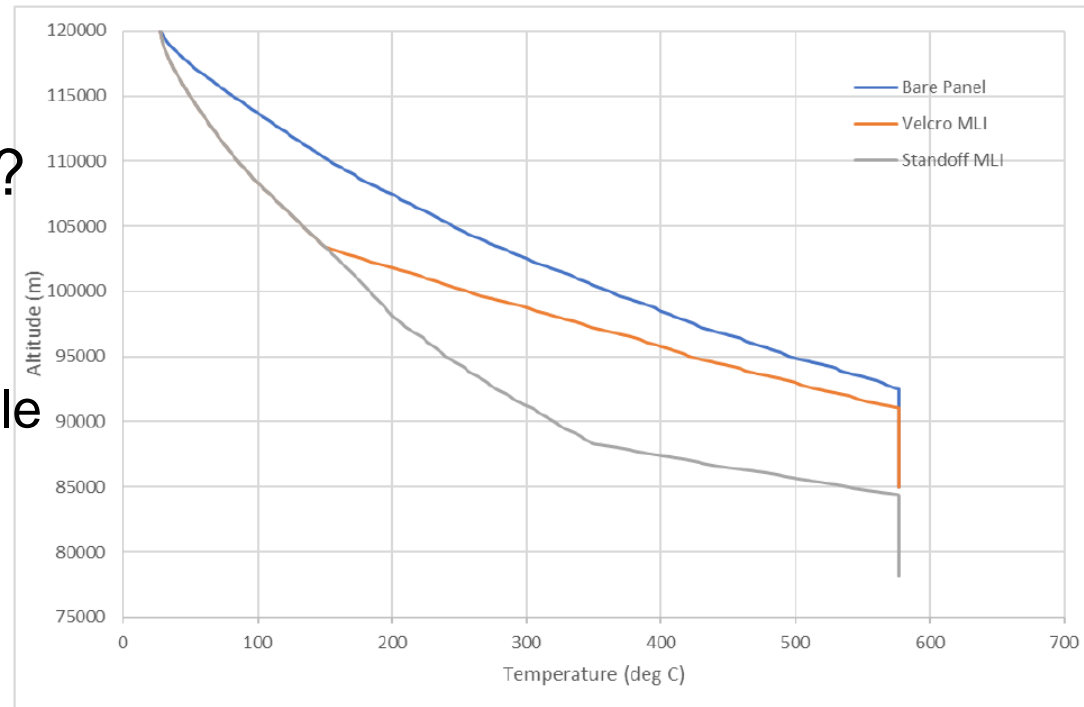
- Bulk Heating Model

- Verified on test data
- Applicable to flight

Heat Flux (kW/m ²) Nominal	Heat Flux (kW/m ²) Calibrated	Scale Factor
<5000	<3500	0.5
5000	3500	0.5
20000	14000	0.27
50000	35000	0.23

Extrapolation to Flight

- Trajectory of 2m Cube
 - Assess behaviour of external panels
- MLI Insulation Effect
 - Clearly observed
 - Standoffs significant
- Closer to Observation?
 - Open question
 - Sensible result
 - 85km still reasonable



Conclusions

- Clear Impact of MLI
 - Insulation is real
 - MLI likely to stay in place until Velcro melt / front facesheet goes
 - Model constructed to account for this
 - Proxy model, could be implemented in DRAMA
- Reduction of Joint Failure Altitude
 - Towards observed data (which is on steeper trajectories)
 - Fragmentation still suggested to be clearly higher than 78km