

QARMAN re-entry CubeSat : Preliminary Results of SCIROCCO Plasma Wind Tunnel Testing



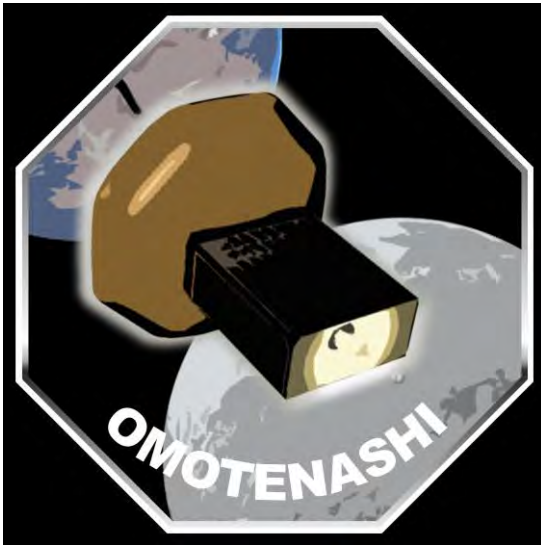
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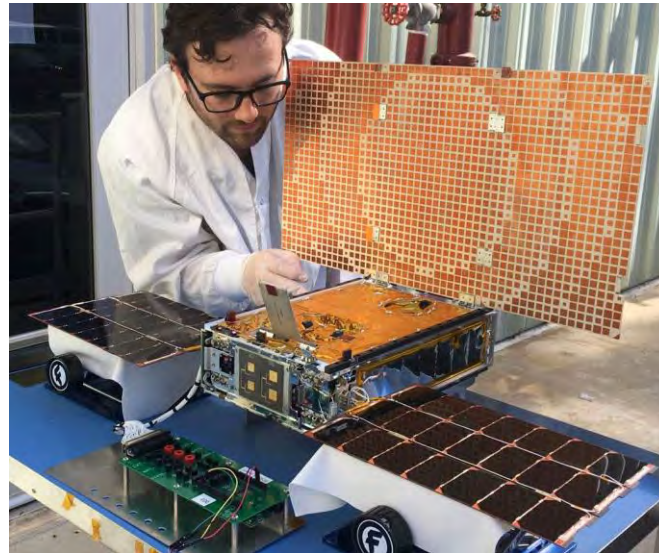
¹VKI, ²CIRA

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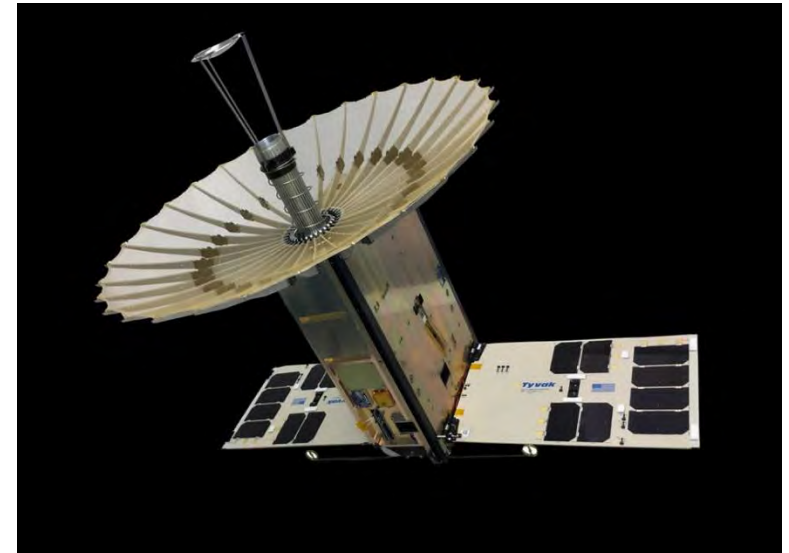




JAXA credit

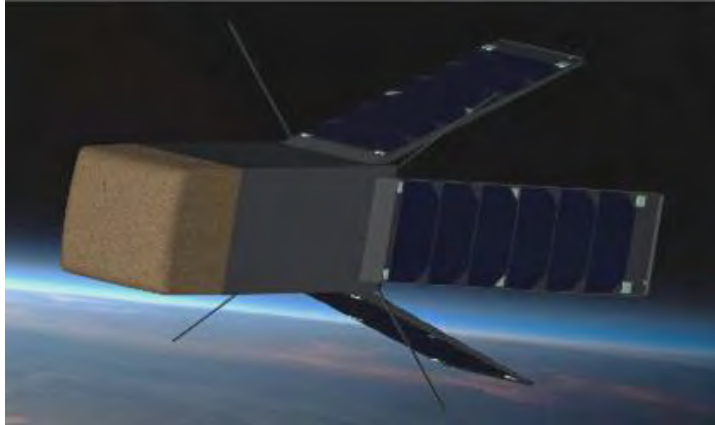


NASA/JPL credit



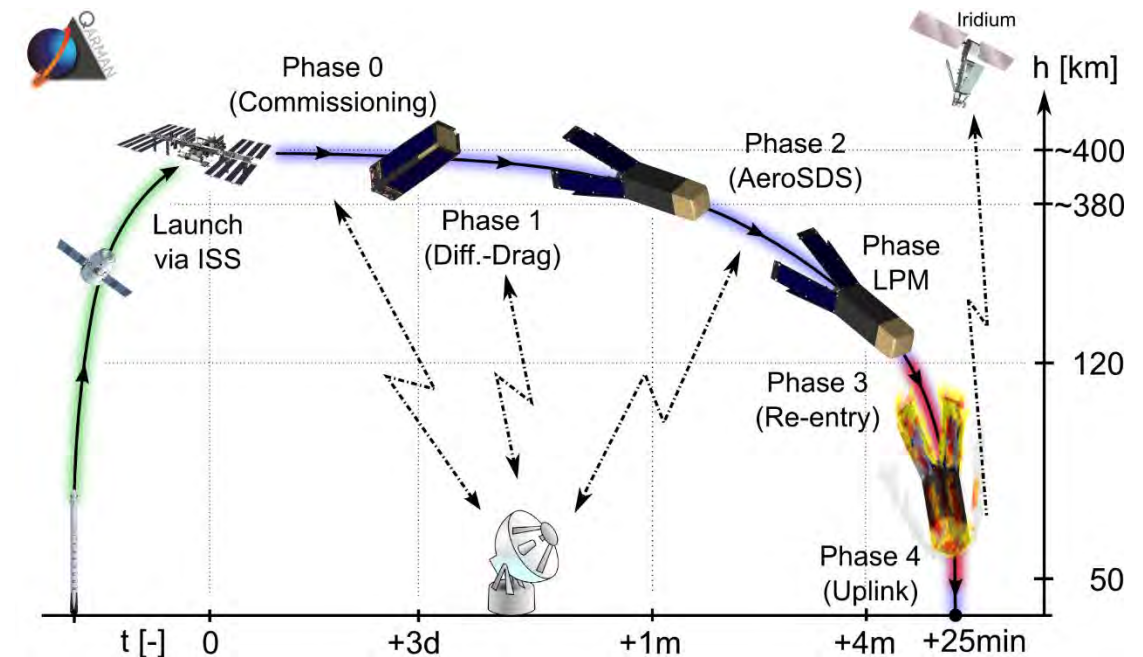
NASA/JPL credit

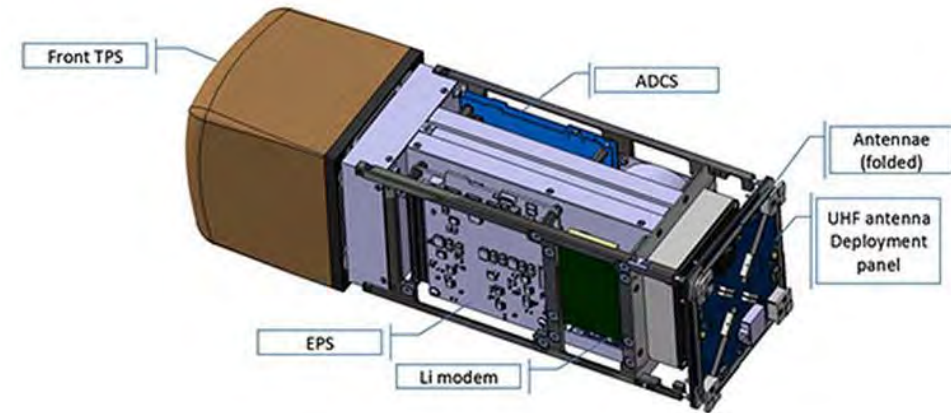
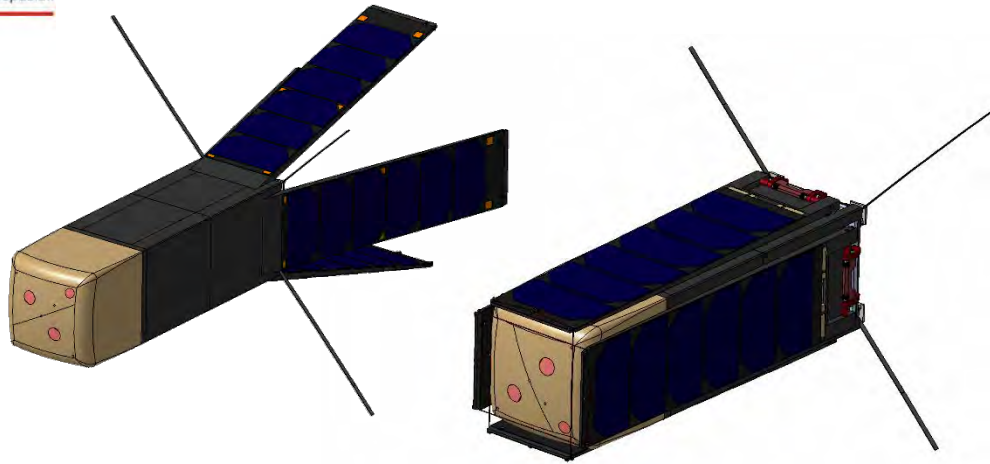
Can We Be Disruptive in Our Own Way?



- QARMAN (Qubesat for Aero-thermodynamic Research and Measurements on Ablation) is a 3U CubeSat, funded by ESA GSTP, designed and manufactured by VKI

- Demonstrate the feasibility of a CubeSat as a re-entry platform
- Thermal and Structural design validation
- Scientific Investigation (XPLs)
- Communication system

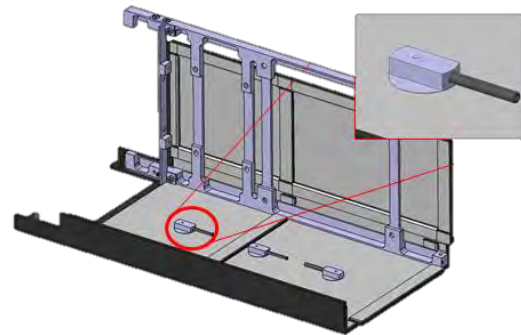




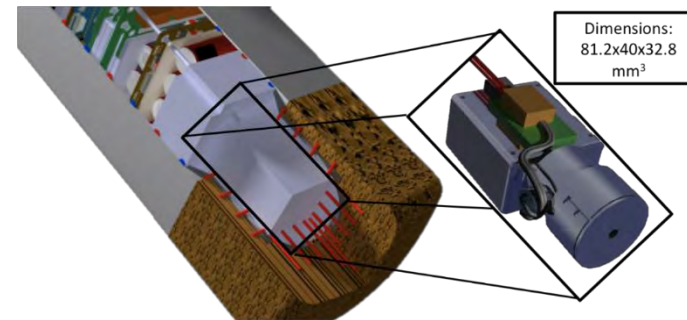
Thermal Plugs and Ablative Material



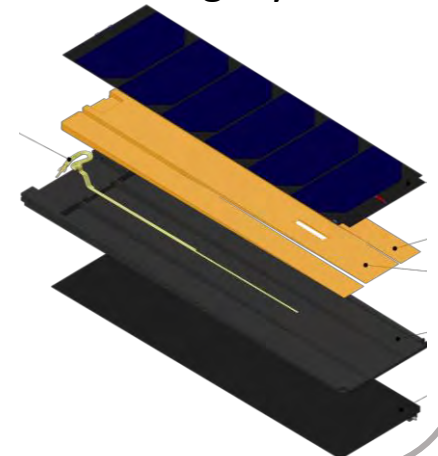
Side Panels and Pressure Ports



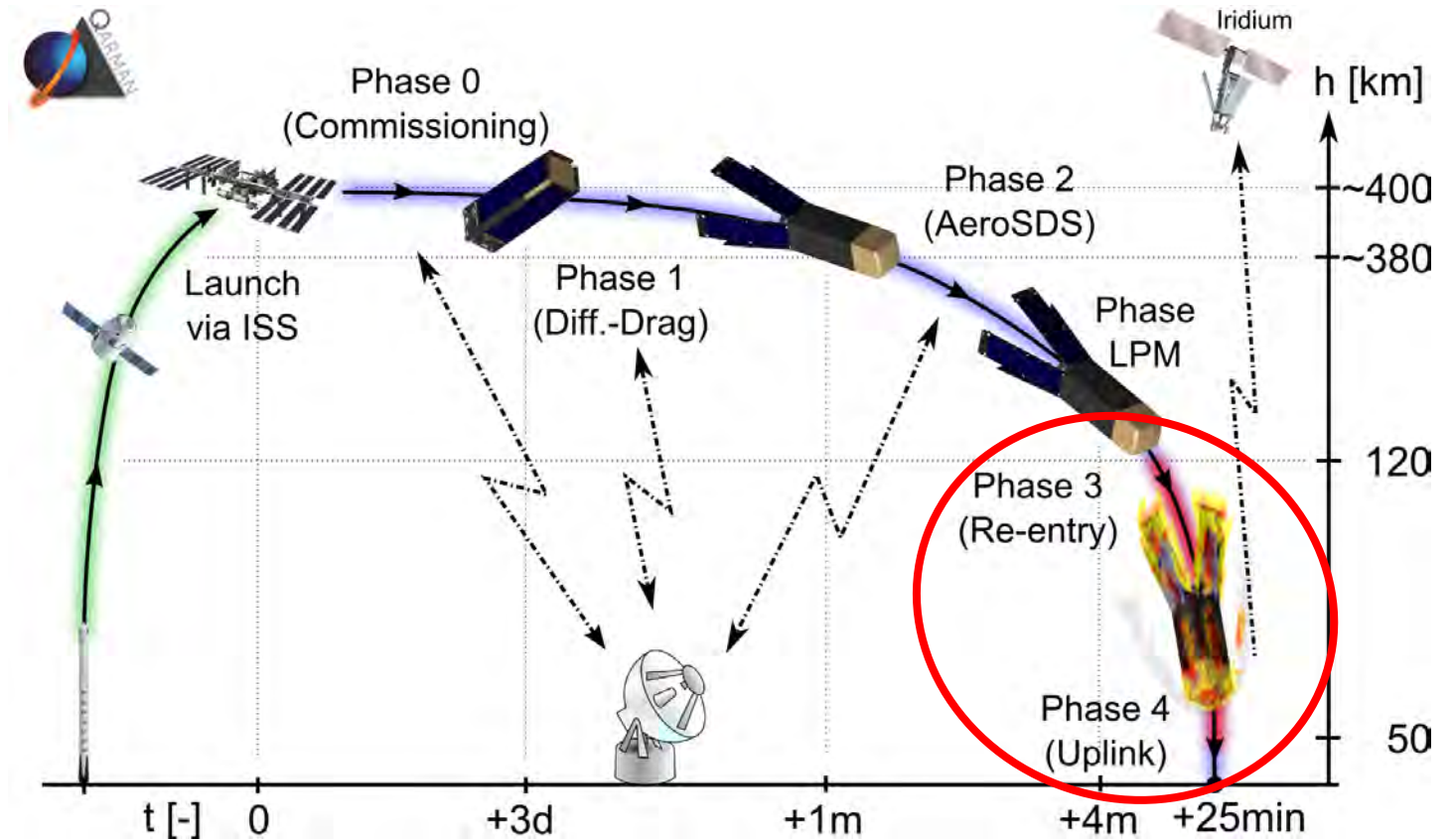
Spectrometer for Plasma Characterization



Stability and Integrity



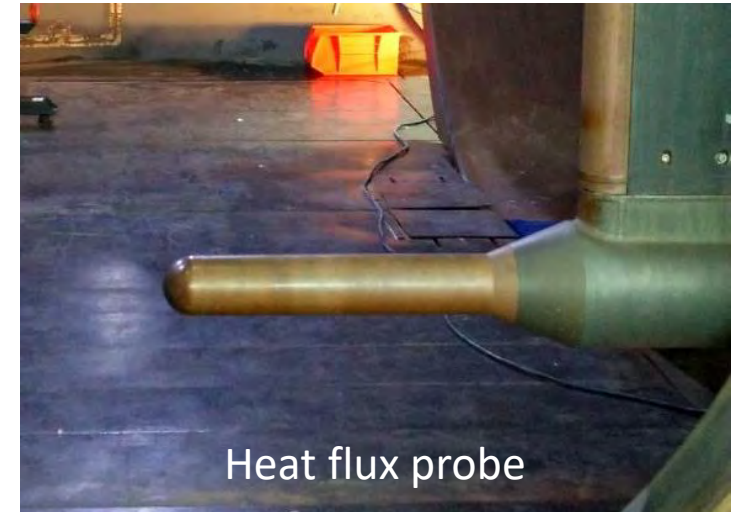
- Test in SCIROCCO conducted in the framework of a collaboration between CIRA and VKI
- Duplicate on ground the integral heat load of reentry phase
- Validate thermal modelling
- Verify structural integrity
- Verify operational temperature of on-board computer during data downlink



- World's largest and more powerful hypersonic arc-jet facility
- 70MW max arc heater electrical power
- Mach 3÷12 plasma jet
- 2m max nozzle exit diameter
- 3.5kg/s max gas flow rate
- Test duration up to 30min

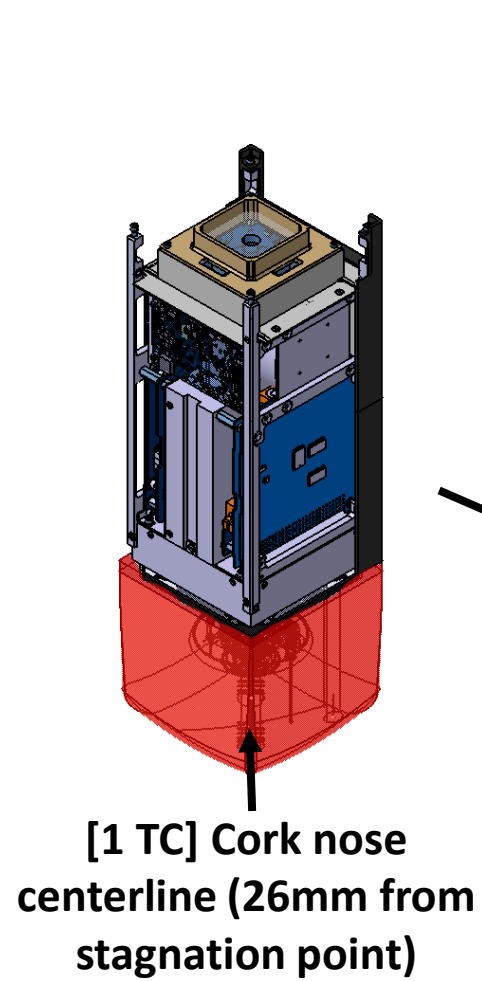


Nozzle exit diameter	903 mm
Mach number	7
Velocity	~6 km/s

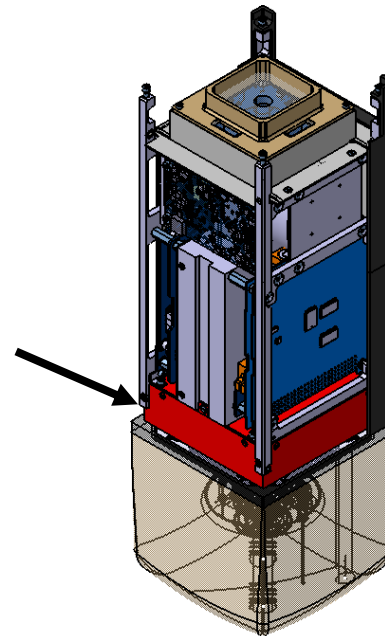


	Target	Measured
Probe Stagnation Heat Flux	2120 kW/m ²	2178 kW/m ²
Probe Stagnation Pressure	40 mbar	39.6 mbar
Air Mass flow rate	0.65 kg/s	0.65 kg/s
Argon Mass flow rate	0.03 kg/s	0.03 kg/s
Total pressure	3.7 bar	3.7 bar
Test Duration	390 sec	395 sec



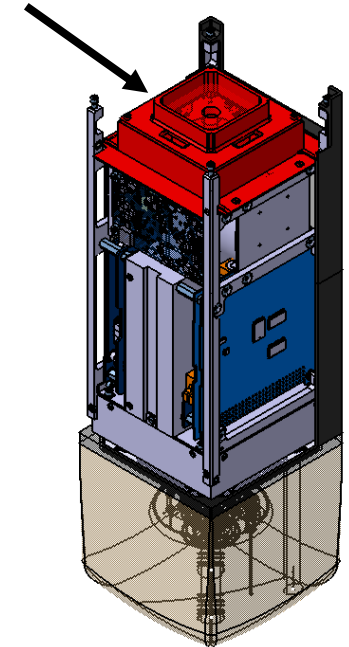


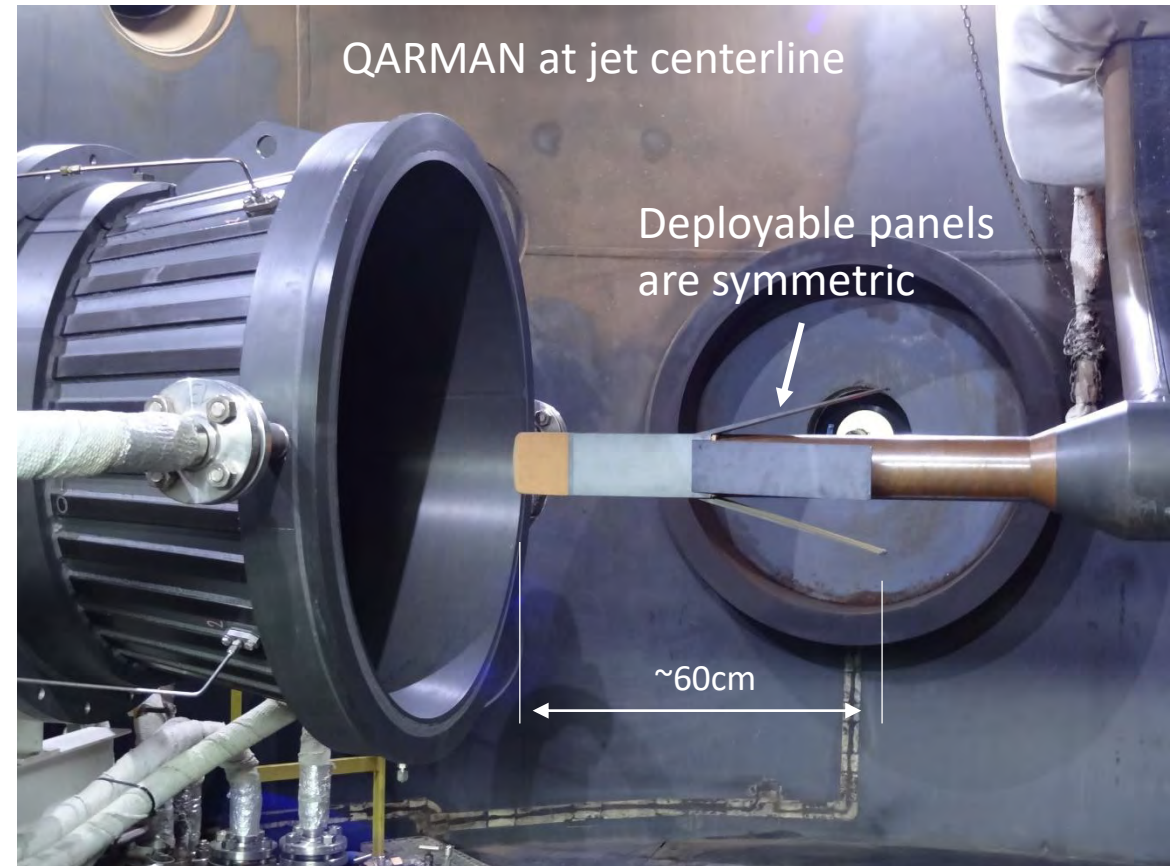
[2 TCs] XPL enclosure
+ electronics



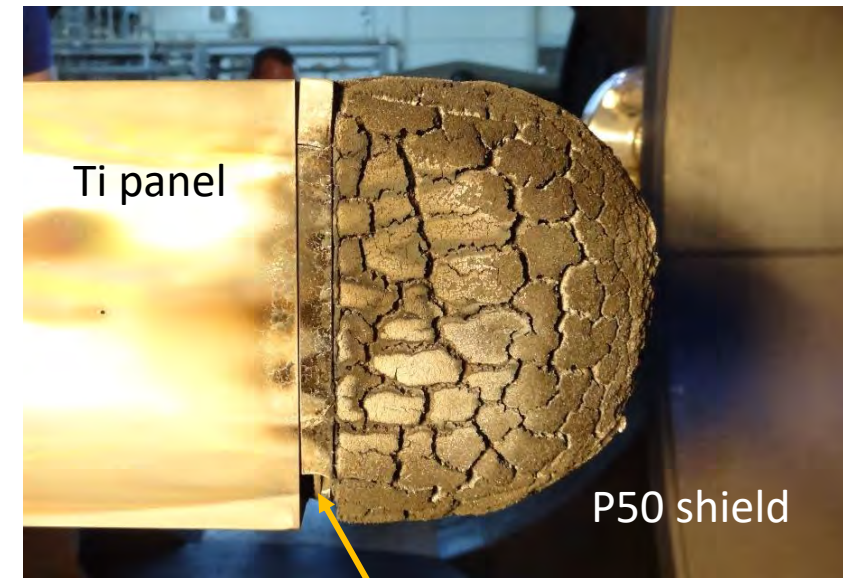
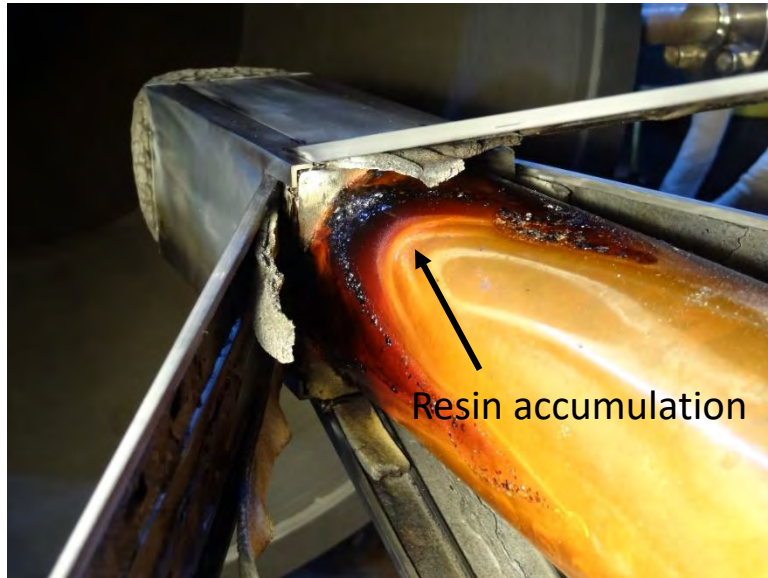
[2 TCs] SU enclosure
+ electronics

[1 TC] AeroSDS
enclosure

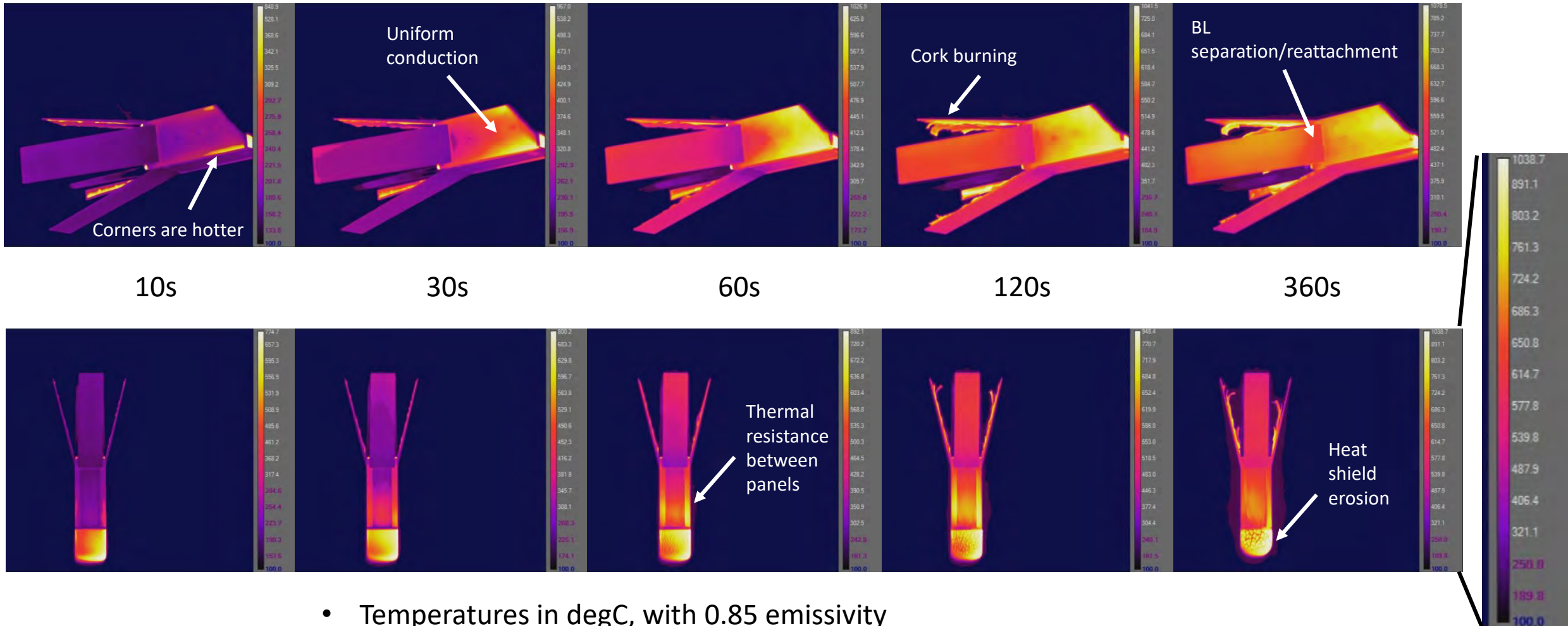




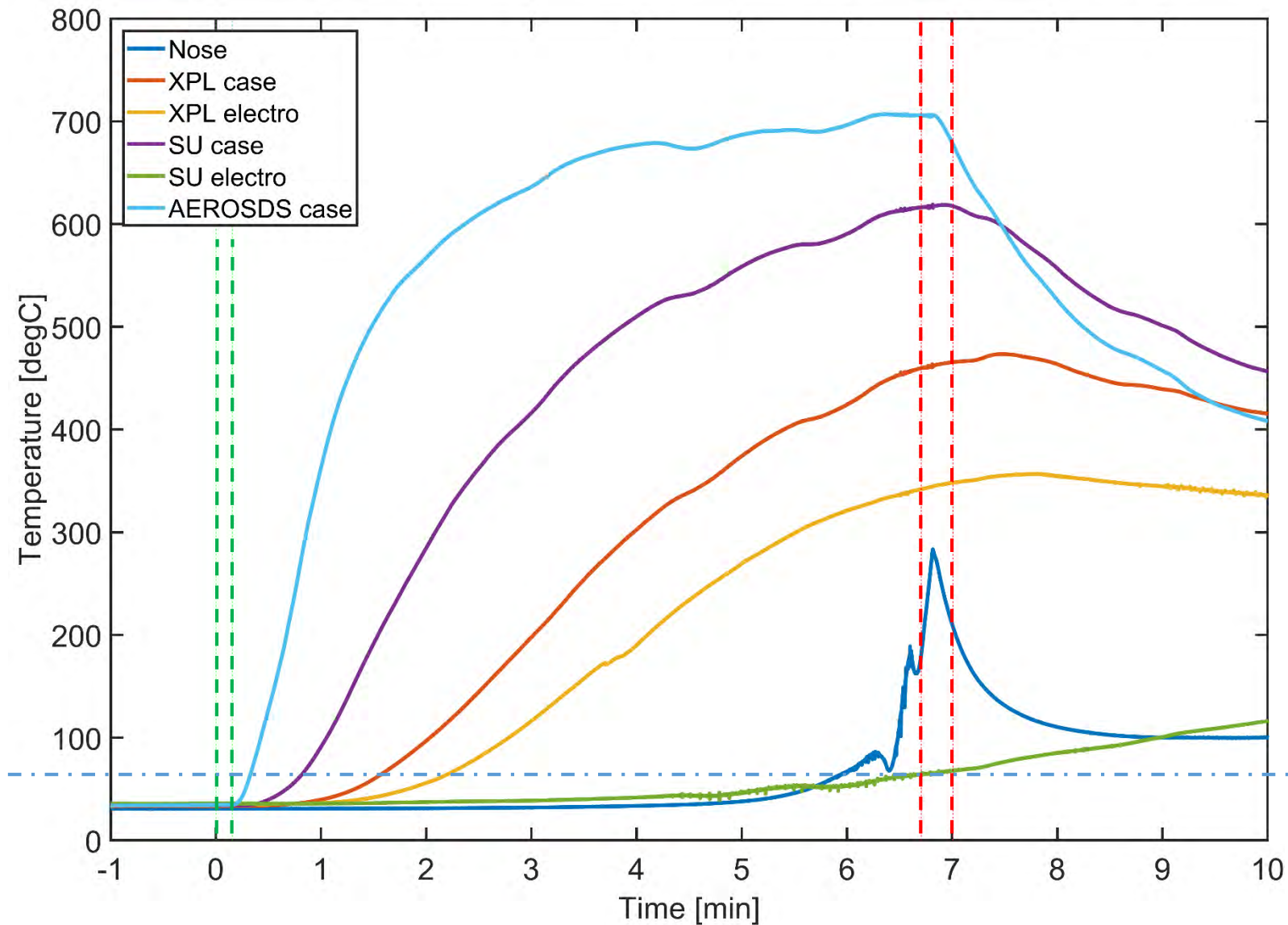
MOVIE



- SiC interface chipped off on corners (P50 rounding exposes SiC)
- P50 resin after sublimation is accumulated in the wake over cooled probe arm
- Cork on leeward side of deployable panels completely burned
- Footprints on Ti panels caused by local increase of heat flux
- P50 recession is not symmetric, eroded more at the bottom

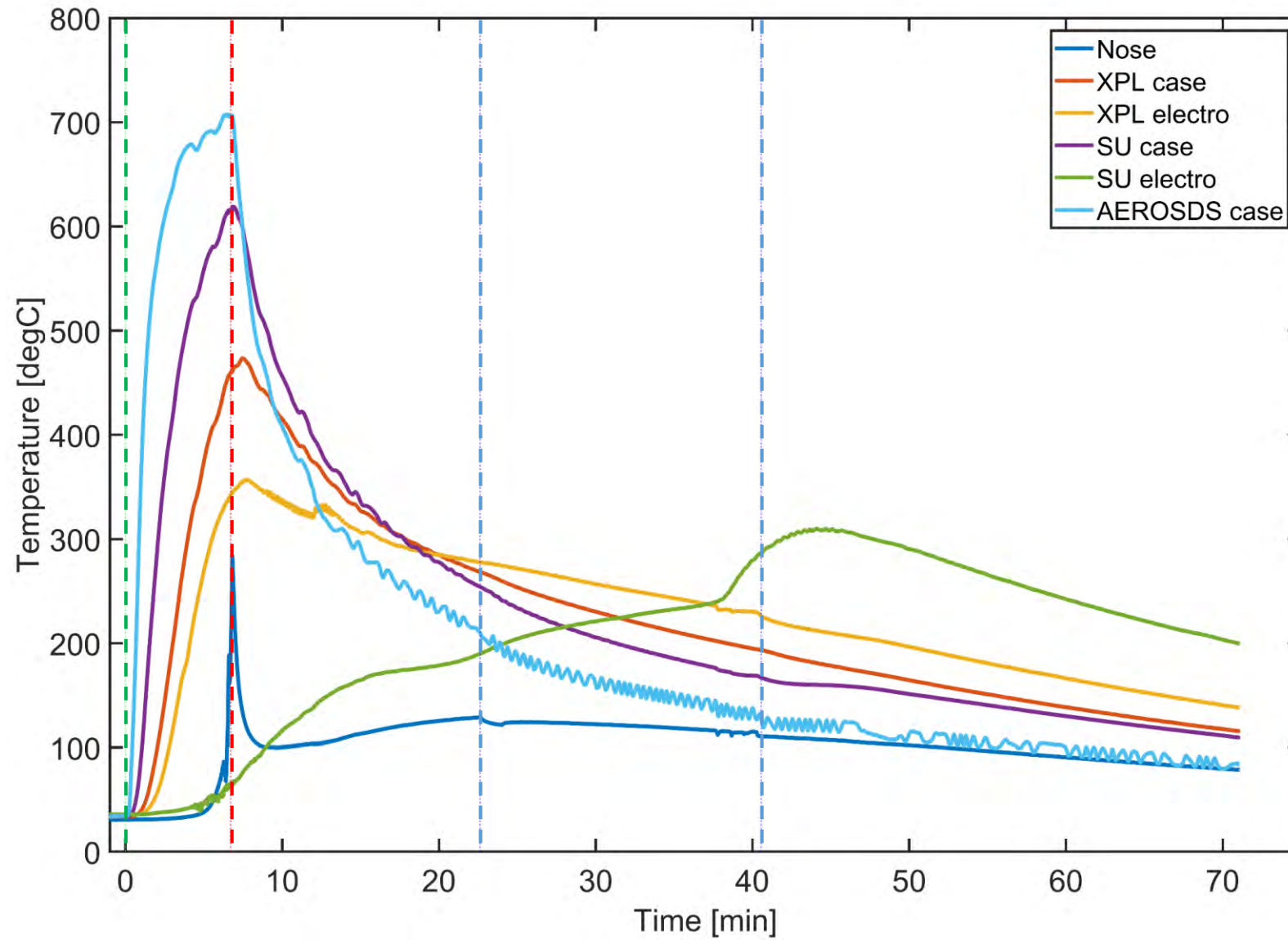


- Temperatures in degC, with 0.85 emissivity
- Infrared data calibration in progress, T increase is expected

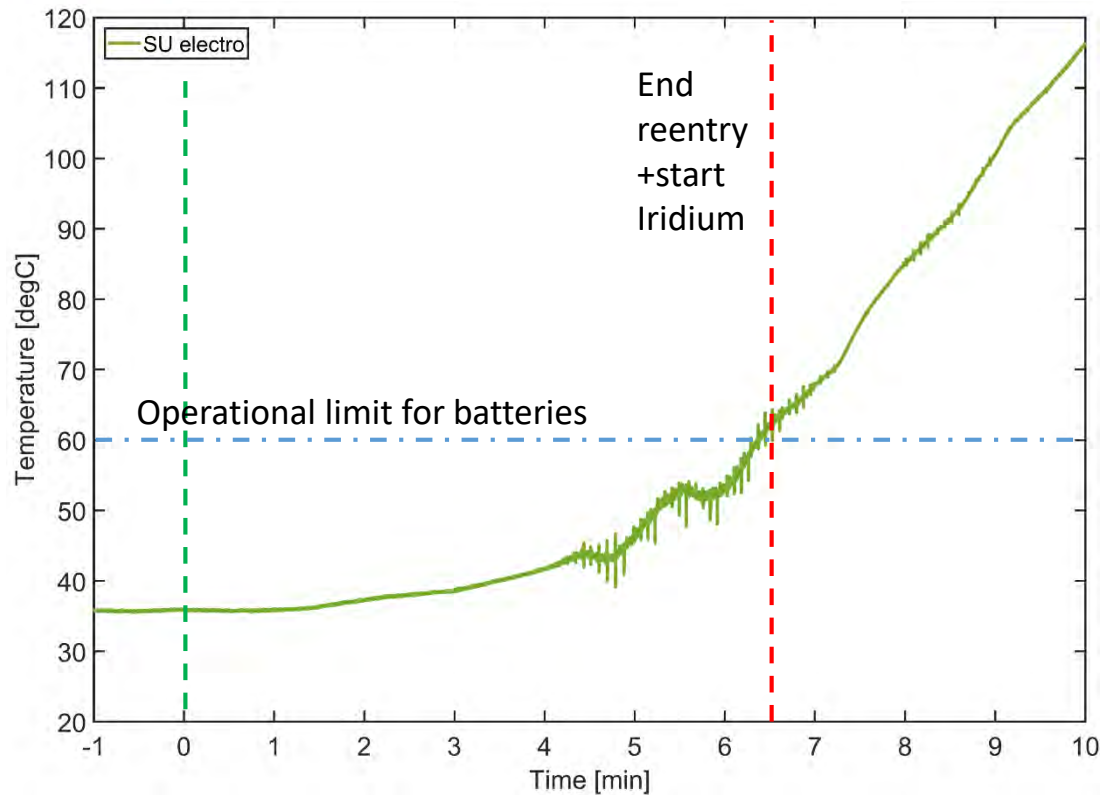


Operational limit
for batteries

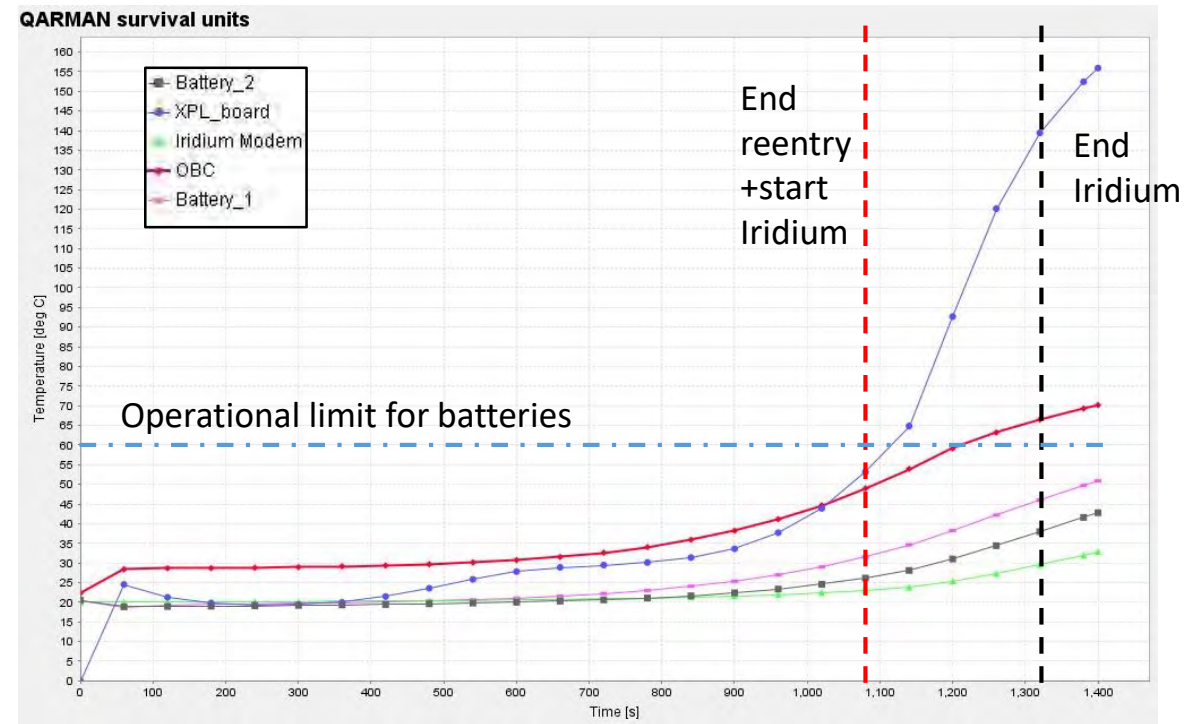
TC Results – Cooling down



EXP



THERMAL MODEL

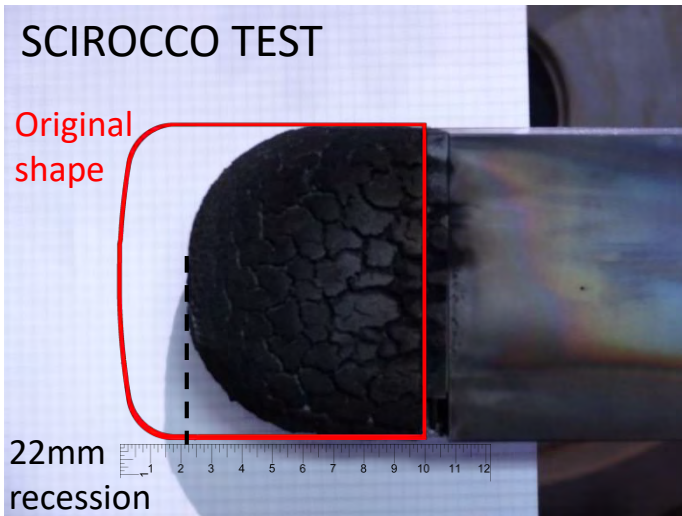


- Operational limit for batteries is reached at 380s in the test (test duration is 390s for full heat load)
- Thermal model shows operational limit of batteries reached 120s few seconds after re-entry
- During the test on-board computer temperature is below the critical limit for electronics (85degC)
- Ripples appear in the TC at 4min in the test (noise? batteries thermal run-away?)

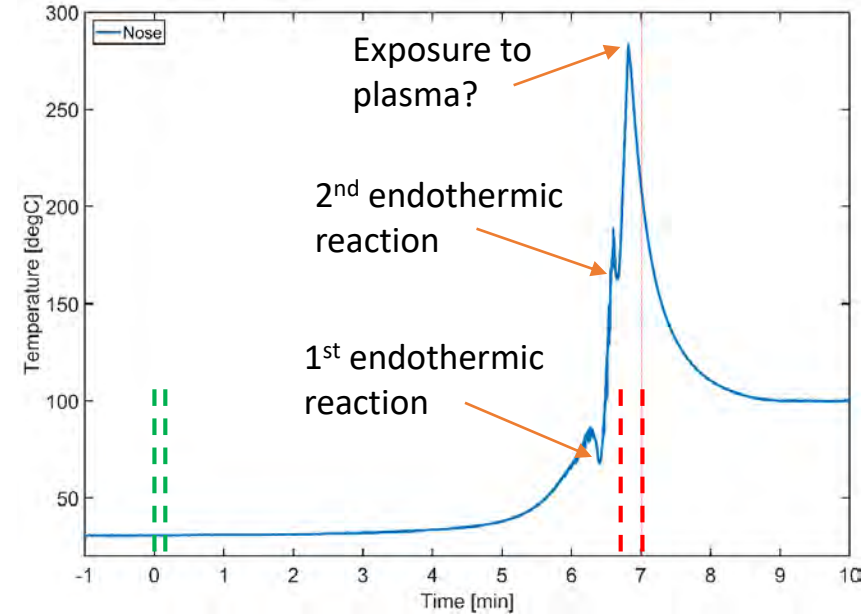
PLASMATRON TEST



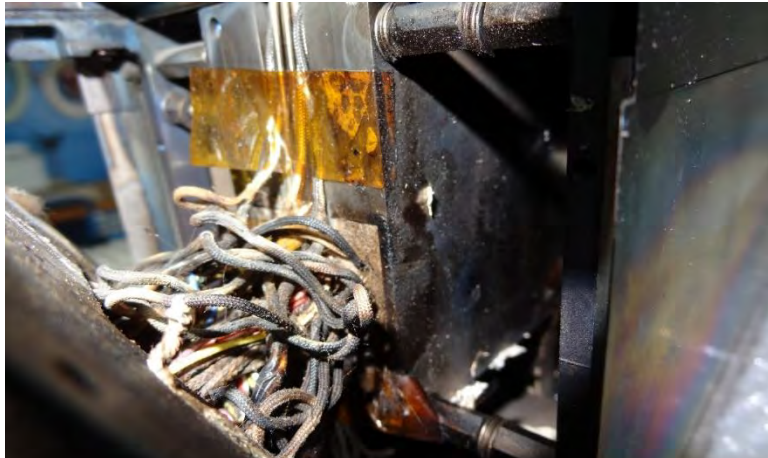
SCIROCCO TEST



SCIROCCO TEST TC



- Similar endothermic valleys already observed at NASA (on PICA material) and at VKI (on P50 material)
- Nose TC (at 26mm) reached by the char region and perhaps exposed to plasma at the end of the test
- Shield erosion after SCIROCCO test is very different from PLASMATRON (different velocity gradients)



- Data cables and thermocouple cables are undamaged
- Silicon tubes for pressure port not melted
- Mechanisms are fully functional (hinge deployables)
- No cracks on deployable SiC panels
- Ti panels, Ti skeleton and Ti cases are undamaged



**Thanks to PWT and
QARMAN Teams!**

Looking for collaboration?