LOW DENSITY SUPERSONIC DECELERATOR (LDSD) SUPERSONIC FLIGHT DYNAMICS TEST (SFDT) PLUME INDUCED ENVIRONMENT MODELLING

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Objectives:

- Provide plume induced heating (radiation & convection) predictions in support of the LDSD thermal design (pre-flight SFDT-1)
- Predict plume induced aerodynamics in support of flight dynamics, to achieve targeted freestream conditions to test supersonic deceleration technologies (post-flight SFDT-1, pre-flight SFDT-2)

Approach:

- Star48 and Small Solid Nozzle Flow Fields – *RAMP* engineering code
- Star48 and Small Solid Plume Flow Fields – *Loci/CHEM 3.3* CFD code
- Plume Radiation – *Reverse Monte Carlo (RMC)* radiation code
- Reynolds Averaged Navier-Stokes (RANS) Simulations (varying fidelity, grids)
- Two-phase Flow (Gas + Al_2O_3 particles)
- Two Gaseous Species (thermally perfect, equivalent air and plume, frozen chemistry)
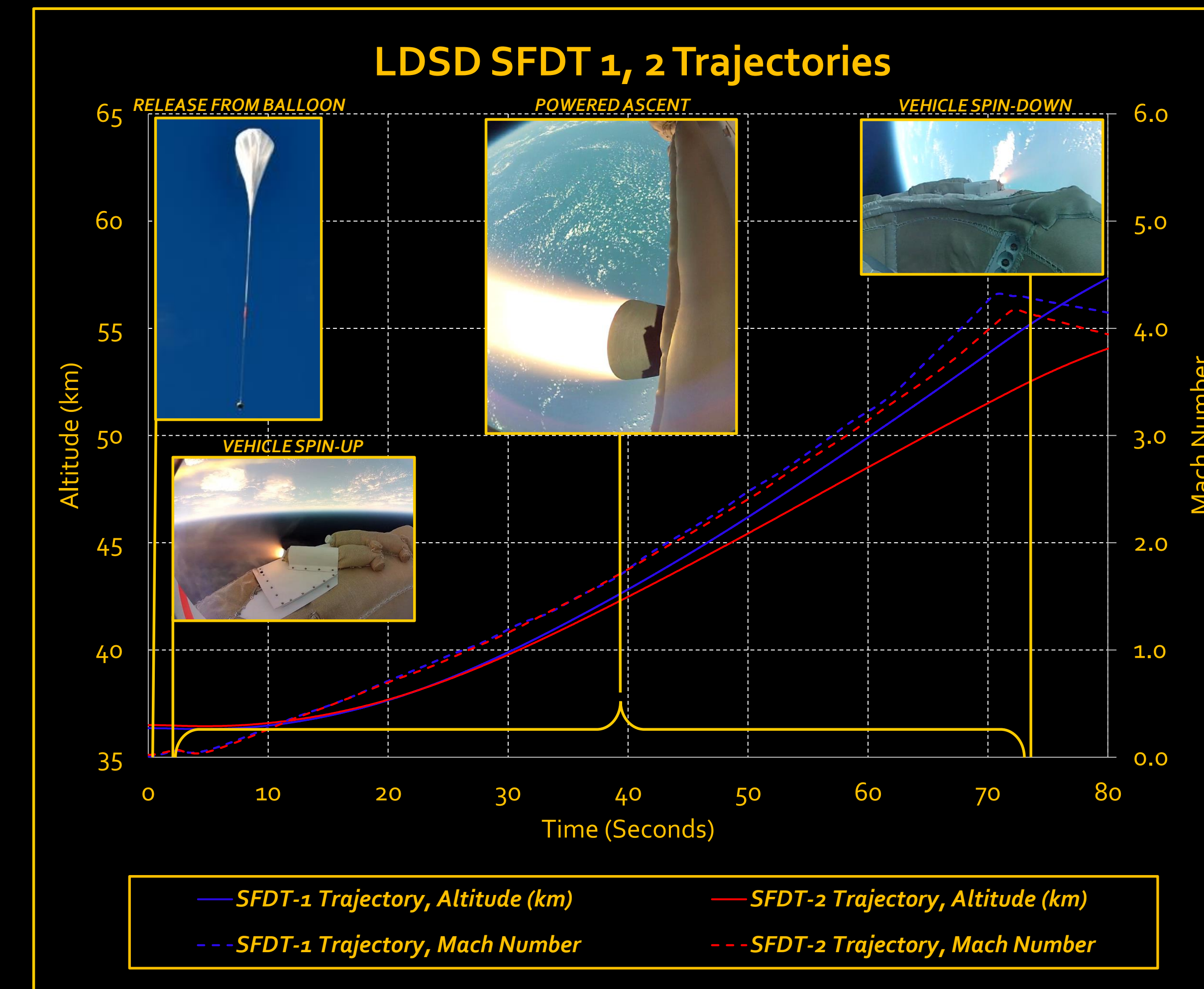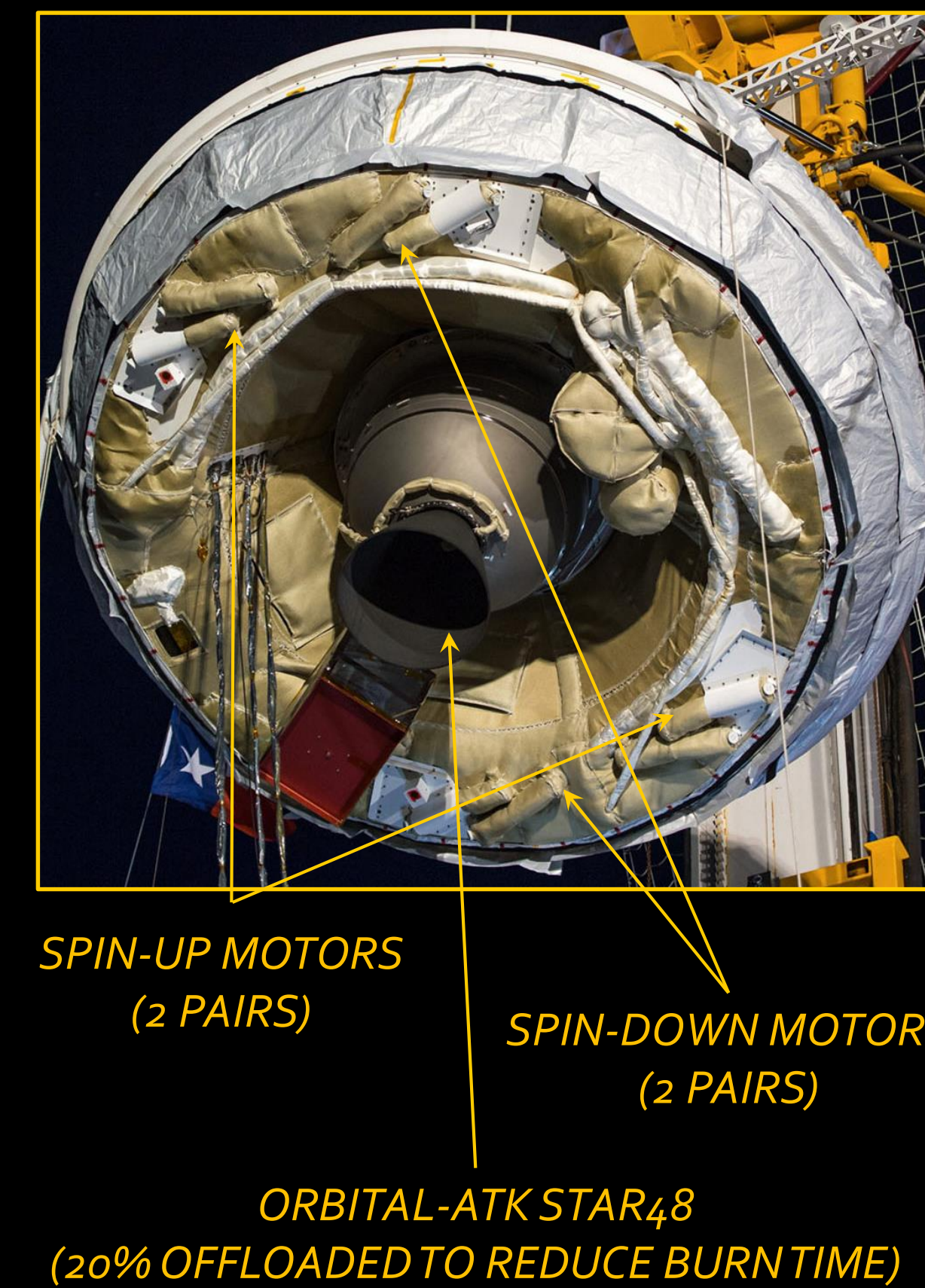
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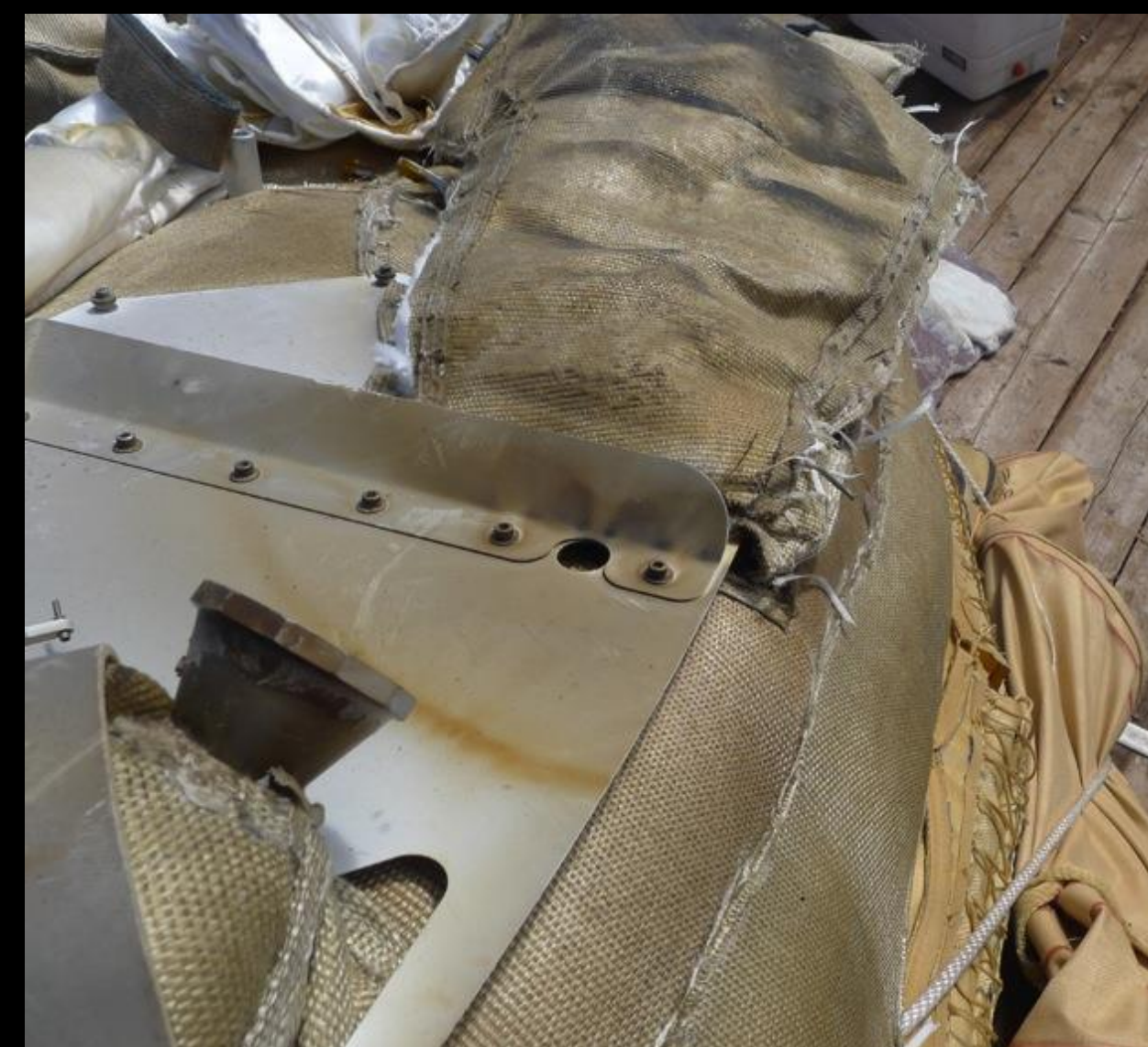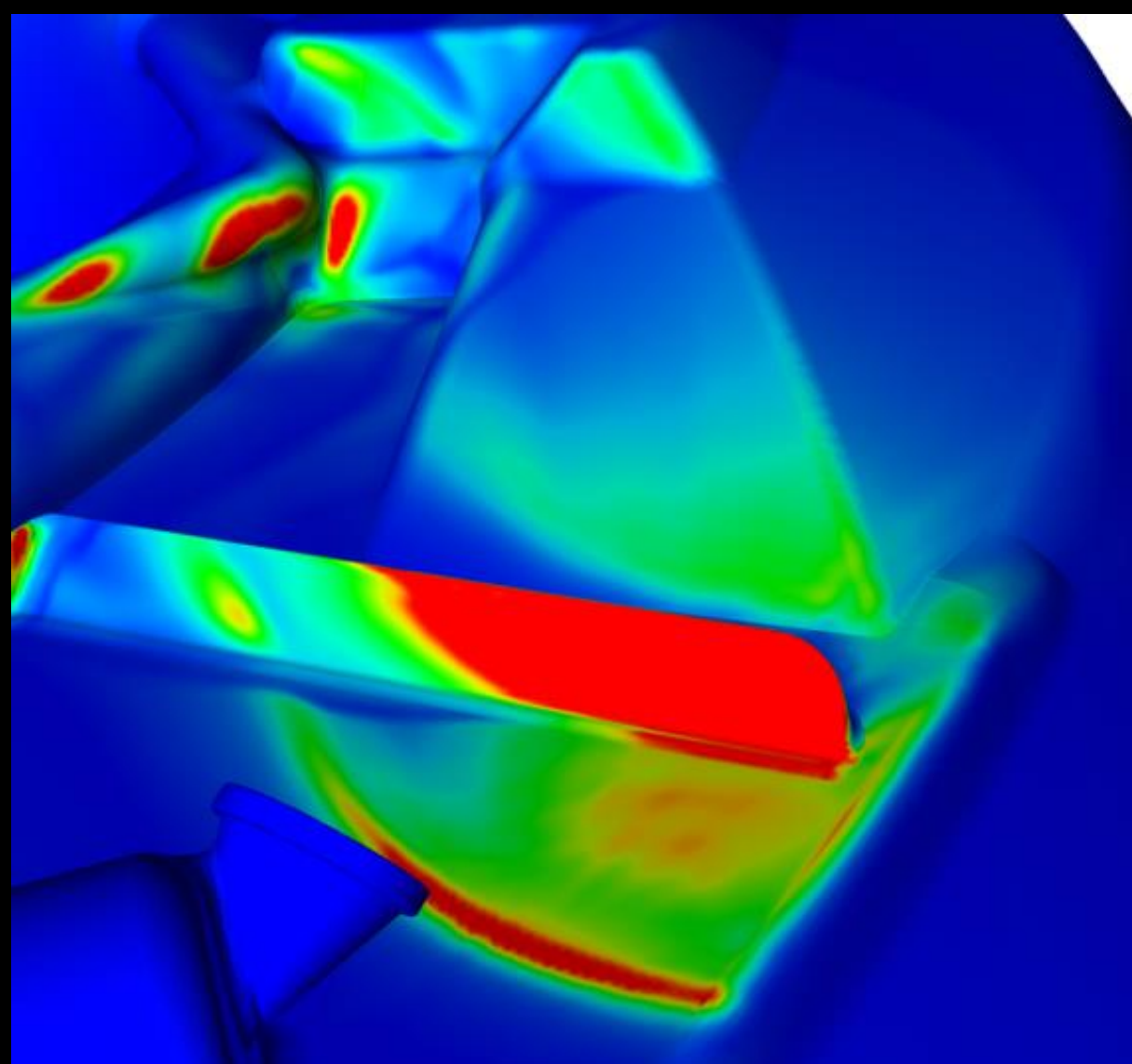[4] Research Scientist, ERC, Mountain View, California, 94035
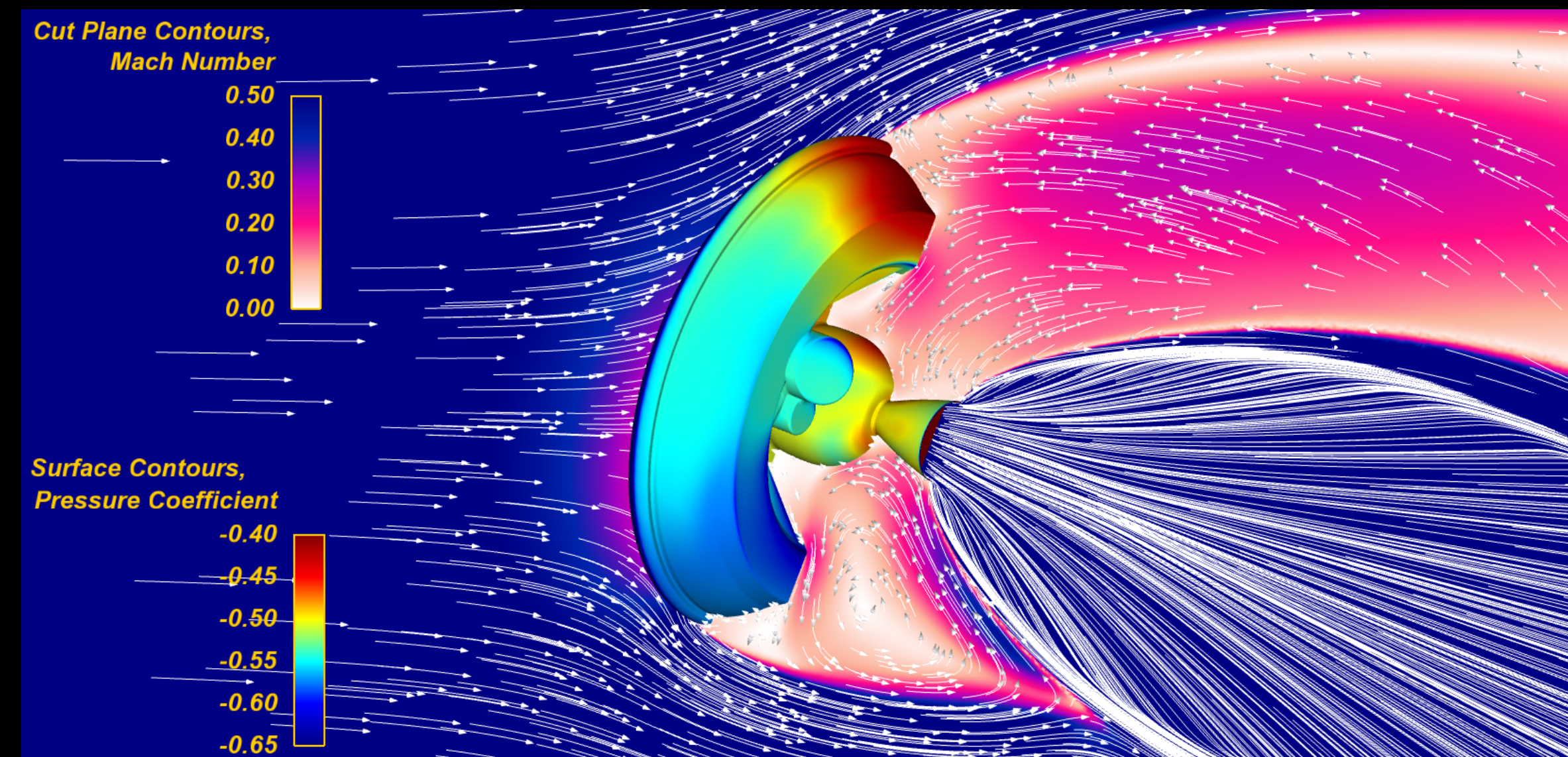[5] LDSD Principal Investigator, Jet Propulsion Laboratory, Pasadena, California, 91109

SPIN-UP MOTORS (2 PAIRS)

SPIN-DOWN MOTORS (2 PAIRS)

ORBITAL-ATK STAR48 (20% OFFLOADED TO REDUCE BURN TIME)

LDSD SFDT 1, 2 Trajectories

RELEASE FROM BALLOON

POWERED ASCENT

VEHICLE SPIN-DOWN

VEHICLE SPIN-UP

- SFDT-1 Trajectory, Altitude (km)
- SFDT-2 Trajectory, Altitude (km)
- SFDT-1 Trajectory, Mach Number
- SFDT-2 Trajectory, Mach Number

SFDT-1 SPIN MOTOR PLUME IMPINGEMENT

Pre-flight Heating Contours

Post-flight Charring

SFDT-2 STAR48 PLUME INDUCED AERODYNAMICS
CFD, Mach = 0.7, Angle-of-Attack = 17.1°

Cut Plane Contours, Mach Number
0.50 0.40 0.30 0.20 0.10 0.00

Surface Contours, Pressure Coefficient
-0.40 -0.45 -0.50 -0.55 -0.60 -0.65

Loci-CHEM CFD AERODYNAMIC PREDICTIONS VERSUS POST-FLIGHT, BEST EQUIVALENT TRAJECTORY (BET)

SFDT-2 Powered Phase, $0.1 \leq M_\infty \leq 1.6$

SFDT-2 Powered Phase, $0.1 \leq M_\infty \leq 4.1$

SFDT-2 Base Pressure, $0 \leq M_\infty \leq 4.1$

Surface Contours, Pressure Coefficient
-0.65 -0.60 -0.55 -0.50 -0.45 -0.40

SFDT-1 Powered Phase, $0.1 \leq M_\infty \leq 1.6$

SFDT-2 Powered Phase, $0.1 \leq M_\infty \leq 1.6$