NWTF
NATIONAL WIND TUNNEL FACILITY

UNIVERSITY OF OXFORD

# Low Density Tunnel

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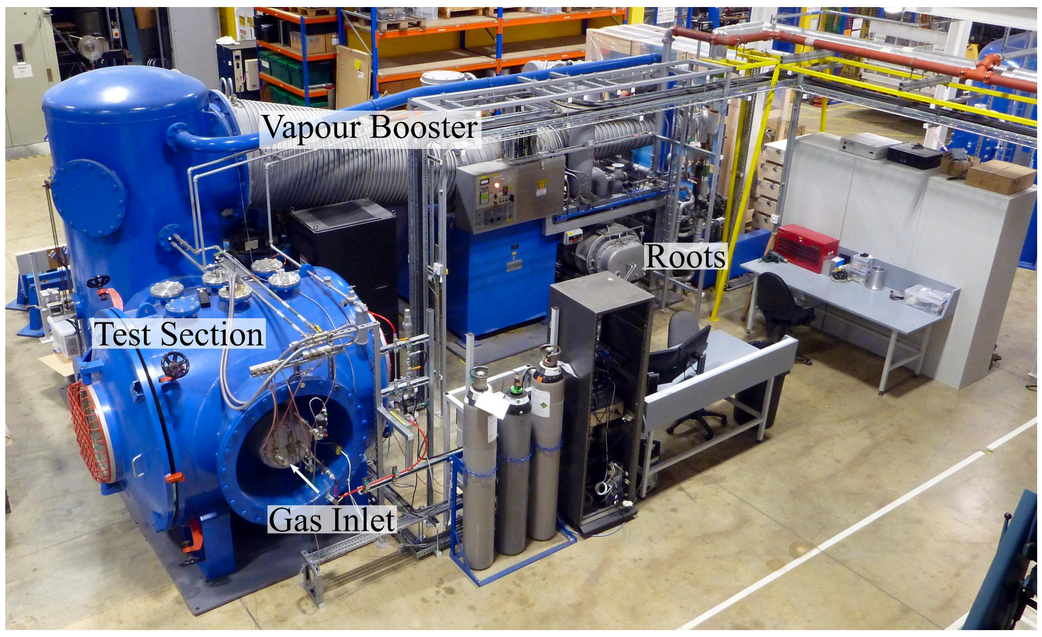
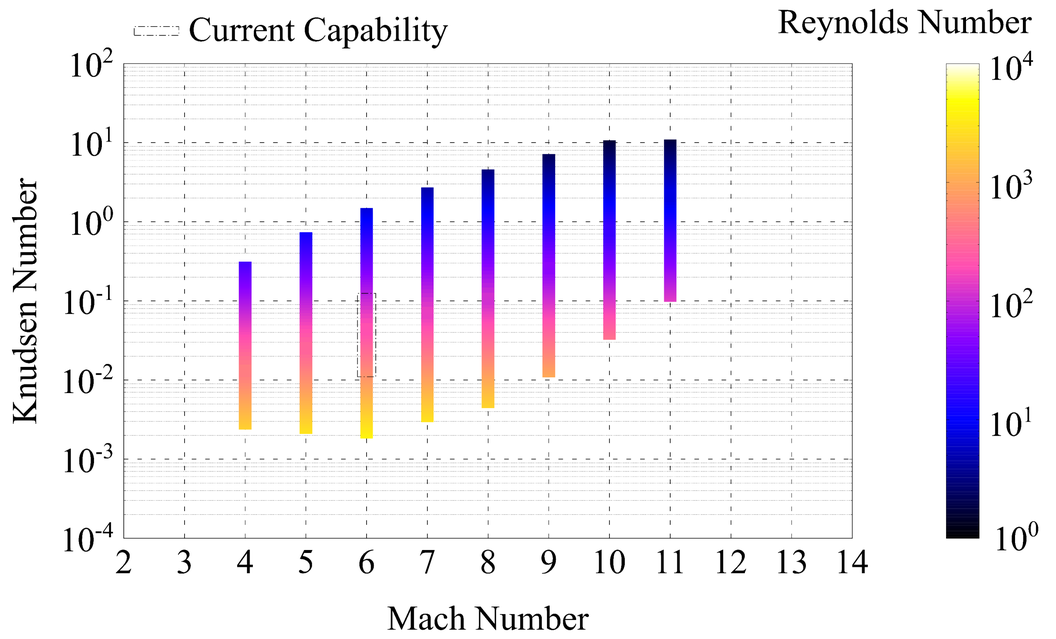



*Above: The LDT facility as installed at the Oxford Thermofluids Institute.*

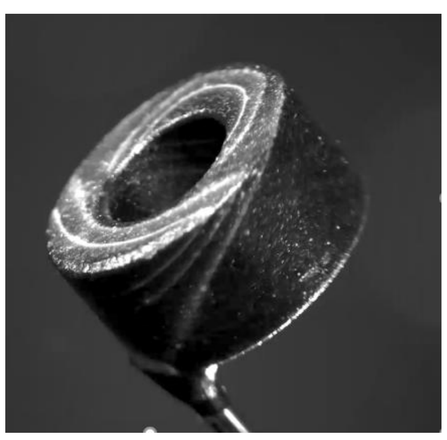



*Above: Theoretical performance map of LDT for a reference length of 10 mm. Calculated assuming isentropic expansion of a thermally perfect gas with fixed core flow diameter of 50 mm. Nozzle supply pressures in the range 1 kPa to 20 kPa and supply temperatures in the range 300 K to 2000 K were considered, subject to facility mass flow requirements. Current capability at Mach 6 corresponds to nozzle supply pressures between 1 kPa and 4 kPa and nozzle supply temperatures between 300 K and 550 K.*

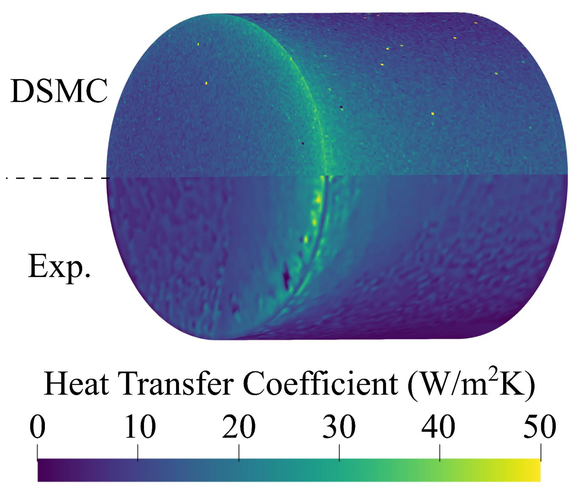
- Continuous, free-jet, open circuit facility. Operates in the hypersonic rarefied slip and transition regimes. Free-molecular flow conditions can be achieved with careful experiment design.
- Knudsen numbers up to ~0.2 for 10 – 15 mm model.
- Currently uses a Mach 6 contoured nozzle; exit diameter 108 mm. Other nozzles to be developed.
- Maximum inlet mass flow ~0.6 g/s. Any inert gas may be used; typically operate with dry air.
- Total temperature capability currently up to 500 K. Can be increased to 1100 – 1350 K with improved inline heaters or to >3000 K with an Inductively Coupled Plasma (ICP) source.

## Recent Research – Heat Transfer on Satellite Geometry Analogues

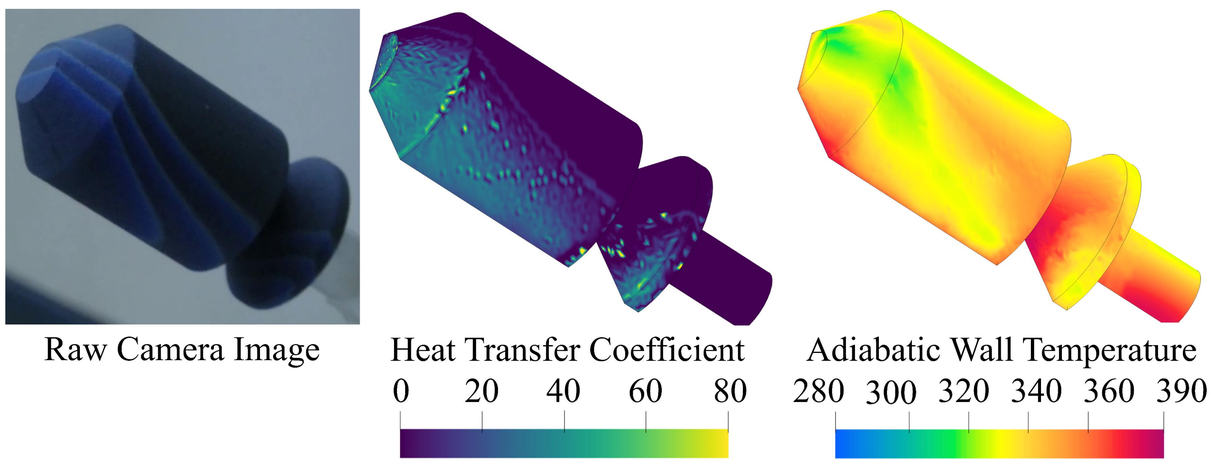
- Non-uniform spatial distribution of heat transfer is measured using thermochromic liquid crystal (LX) thermography.
- Paint is a mixture with LX transition bands of 30°C, 35°C and 40°C (typ.).
- Camera footage processed via. in-house and COMSOL-based techniques – don't need to assume semi-infinite 1D conduction.
- Advantages of technique over discrete gauges or similar techniques such as infrared thermography include:
  1. Standard video cameras can be used at relatively low cost → enables multiple high resolution views
  2. Ability to be used with transparent substrates → enables characterisation of surfaces otherwise unobservable
- Recently upgraded cameras to 2 x Ximea MC031MG-SY with resolution 3.1 Mpix (2064 x 1544) at 122 fps.



*Left: Raw camera image of hollow cylinder at Kn = 0.02, Mach = 5.4 at 45° angle-of-attack. Model diameter was 15mm with aspect and diameter ratios of 0.5. Recorded at a resolution of 1000 x 1000 at 80 fps. Flow from left-to-right.*




*Left: Comparison of DSMC calculation of heat transfer coefficient with experimental result for a flat faced cylinder at Kn = 0.1 and 45° angle-of-attack. Flow from left-to-right.*




*Above: Experimental results for upper-stage analogue at Kn = 0.02 at angle-of-attack of 60°. Model diameter was 15 mm. HTC in W/m²K, Temp. in K.*

## Industrial & Academic Partners

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