NWTF
NATIONAL WIND TUNNEL FACILITY

# High Density Tunnel

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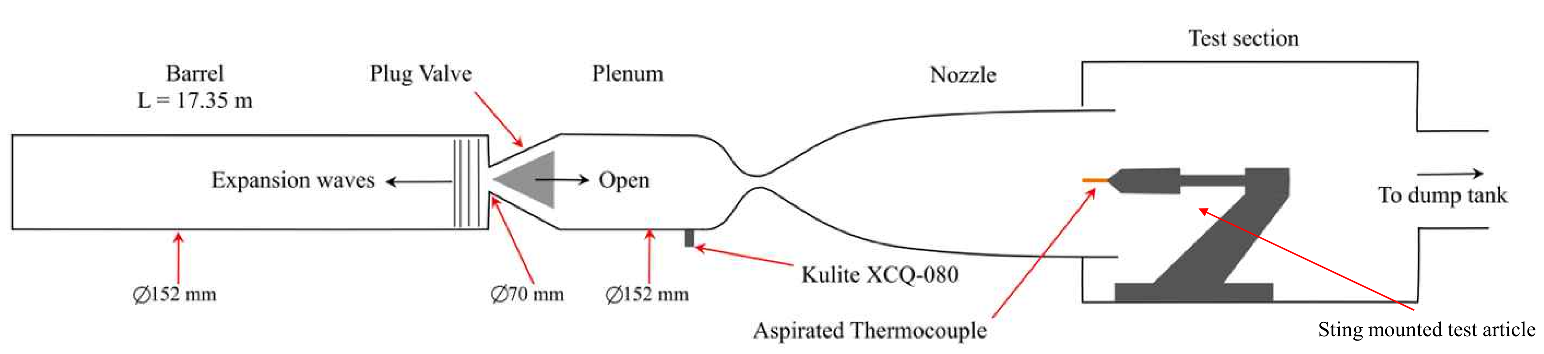
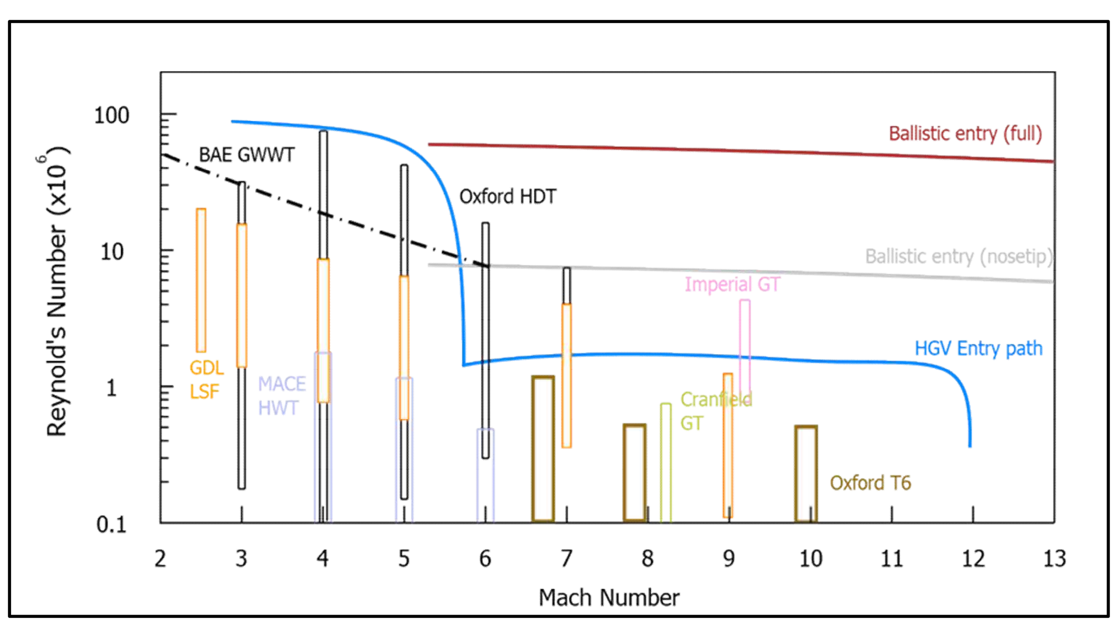
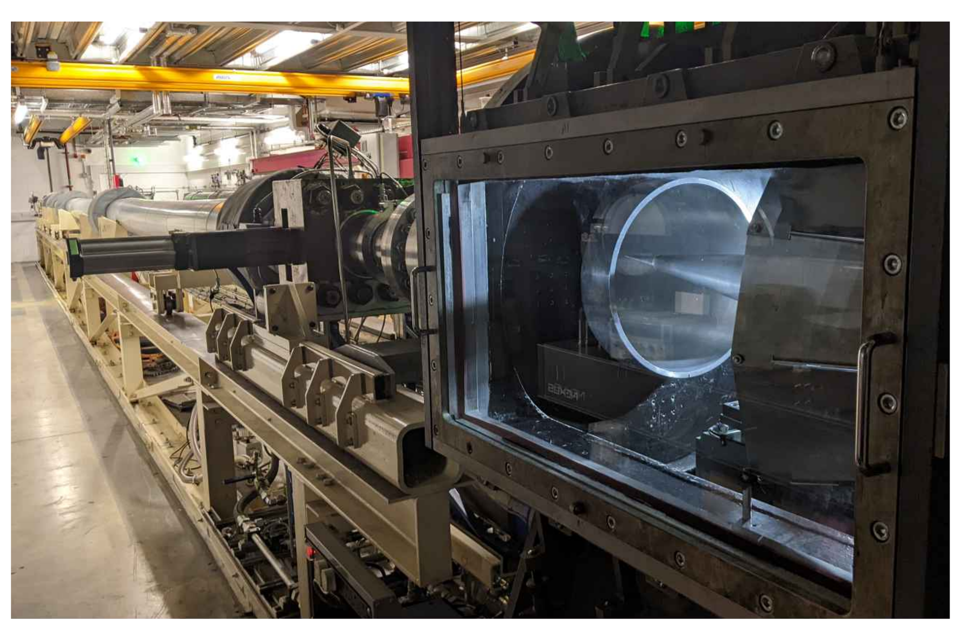
## Facility



HDT performance compared to the theoretical performance of other UK hypersonic facilities

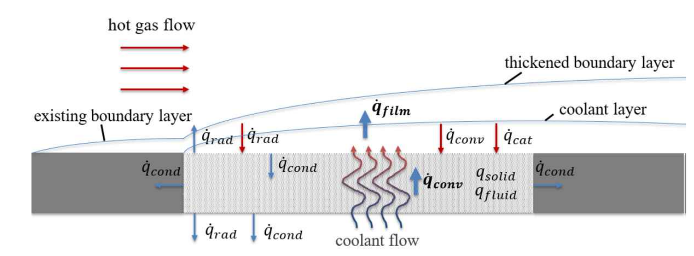

HDT ready to fire with a conical test article

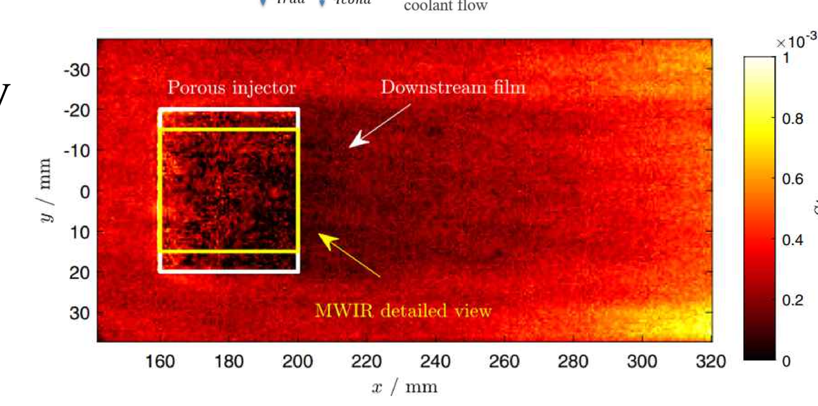
| Configuration | Mach | $P_0$ [bar] | $T_0$ [K] | Test Time [ms] |
|---|---|---|---|---|
| **Ludwieg Mode** | 3 – 7 | 250 | 300 - 550 | 100 x 5 |
| **LICH Mode** (Light Isentropic Compression Heating) | 5 – 7 | 75 | 400 – 1500 | 100 |
| **ELM / PALM** (Extended / Plenum Augmented Ludwieg Mode) | 3 – 7 | 200 | 300 – 550 | 600 |

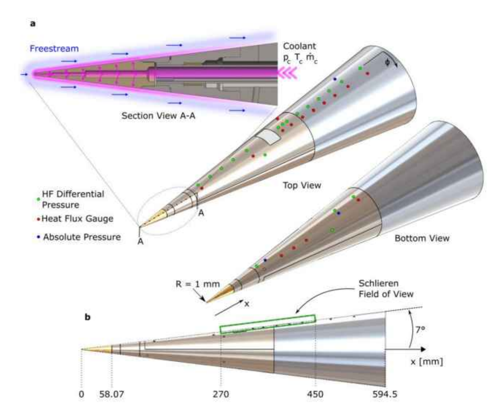
## Industrial & Academic Partners

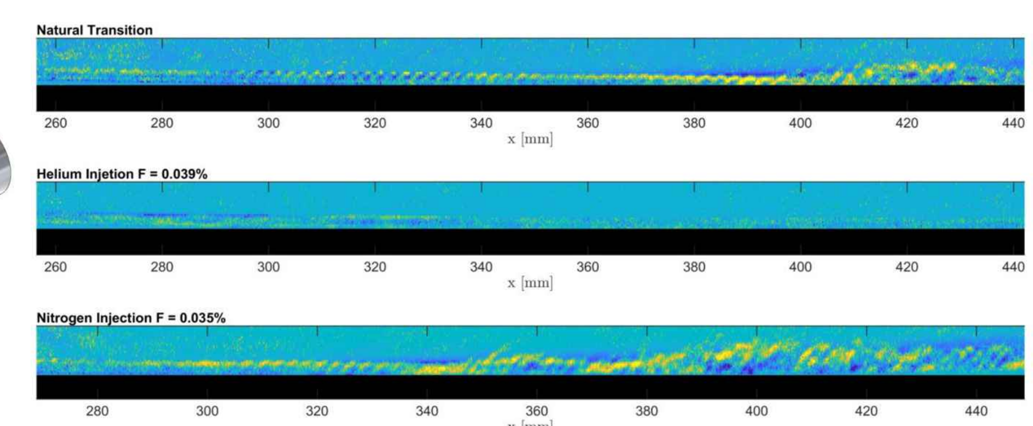
## Transpiration Cooling

- Active cooling technology for cooling of hypersonic vehicle hot spots
- Heat flux, surface concentration and boundary layer transition measurements undertaken over a wide range of hypersonic Mach numbers

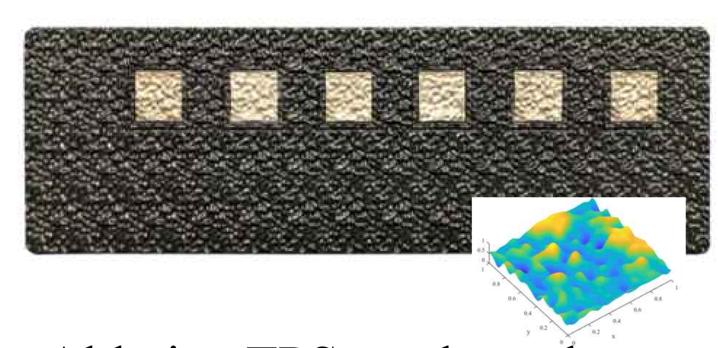


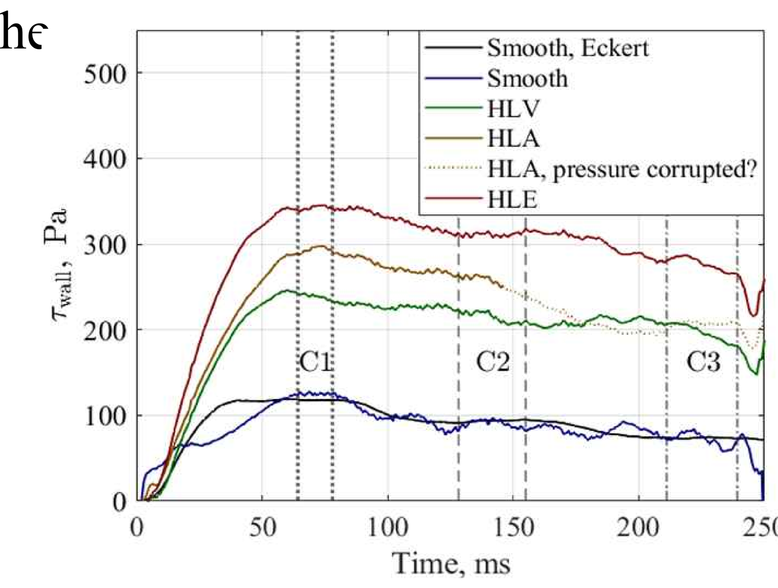



## Large scale roughness



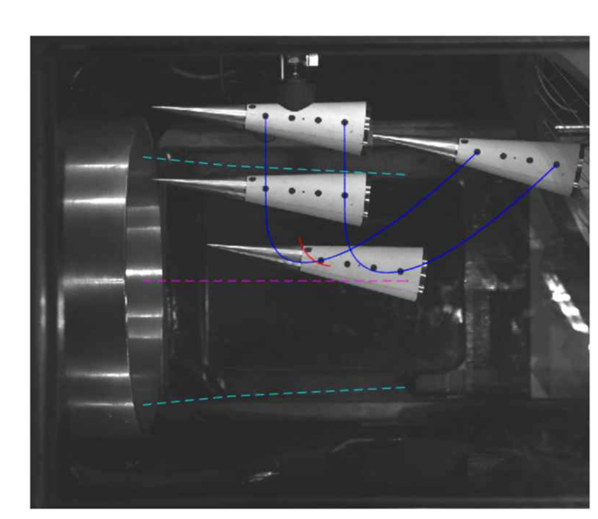
- Ablative TPS produces large scale roughness that can extend significantly beyond the laminar sublayer and sonic line.
- Distributed 2D and 3D roughness surfaces were developed and manufactured for a flat plate test
- Mach 5 boundary layer edge conditions, Re = $30 \times 10^6$

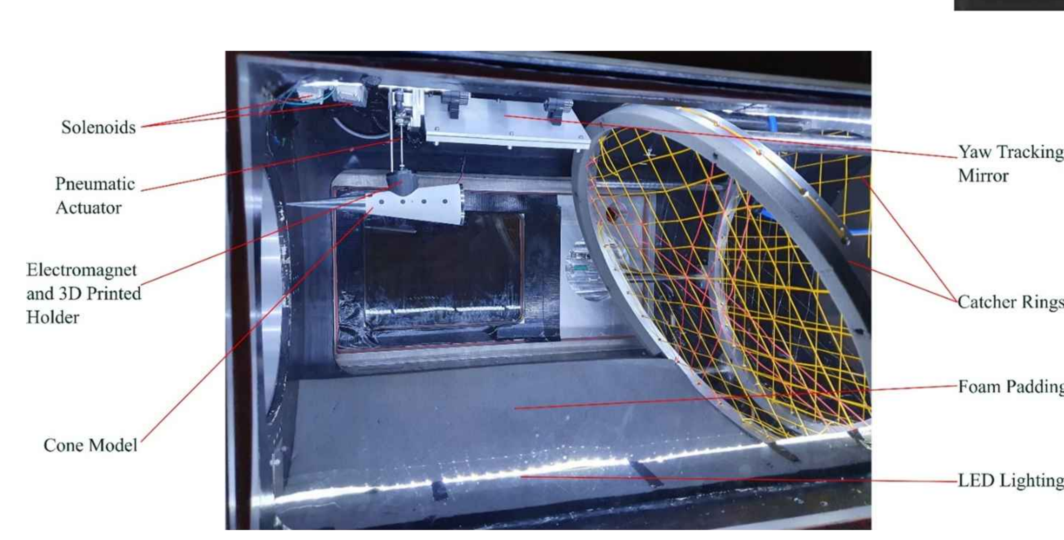
- Novel heat flux measurements using IR thermography, silver calorimeters and TFHTG
- High response shear stress measurements were successfully made using a floating element technique.




## Free-flight aerodynamics

- Free-flight technique allows for higher response, removal of sting and exploration of dynamic coupling
- Model drop co-ordinated to align with tunnel flow startup.
- Forces measured through high speed imaging and on-board IMU






- Free-flight shown to out-perform traditional force balance measurement technique.