UK Academic Centre of Excellence in Hypersonics Science and Technology

Redacted

Oxford Thermofluids Institute

Department of Engineering Sciences

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**Technical Response**

**Introduction**

Hypersonic air vehicles represent both an opportunity and a potential threat. It is vital that MOD and UK industry understand this important area. Other nations have been investing significantly in this area for many years. The aim of the funding from DSTL, Oxford and the RA Eng is to build a self-sustaining, centre of excellence in hypersonics that supports the needs of government, industry and wider academia and can compete on the world stage. Key deliverables include improved facilities, instrumentation and infrastructure, high quality scientific publications and the development of suitable qualified and experienced personnel. It is also hoped that other academic institutions, from the UK and overseas, and industry will be engaging with the group and utilizing its capabilities.

The RA Eng have committed Redacted as a contribution to Redacted salary to enable focus on developing the Hypersonic research capability. The University of Oxford will support this initiative through reinvesting the salary savings enabled by the Fellowship into the new, full time Departmental Lecturer, to covering Redacted teaching and administrative obligations. The appointee will be advertised in an area aligned with high speed flows and they will develop their own research agenda to broaden the expertise and compliment the work of the wider Hypersonics Research Group. The Department will also fund two DPhil (Home) studentships geared towards the fulfilment of the fellowship’s research goals. These investments will greatly increase our research capacity in this area.

**Technical Programme**

The technical programme has been broken into four work packages with associated deliverables/timeline detailed in section 1.6 in the Statement of Requirements.

**WP1: Improved hypersonic facilities**

Work will be undertaken to re-establish the Oxford Low Density Tunnel. This facility is unique in the UK and is capable of reproducing the Knudsen numbers seen during re-entry at high altitudes. Firstly, the facility will be recommissioned and a calibration of the flow properties in the existing Mach 6 nozzle will be performed. Although there is an existing Magnetic Suspension Balance system which enables free flight of models and measurement of forces/moments, this needs refurbishment and commissioning. Finally, a simple test case will be performed and compared to an established rarefied simulation code.

The other two hypersonic facilities in Oxford (High Density Tunnel and T6 Multi-mode Facility) have been operational for the past 4 years. These will be upgraded to enable higher throughput by increasing efficiency of the operation at current pinch points in the pumping system and jigs to enable day to day operations. Additionally, their capability will be expanded to enable operation for longer test times by operation in Extended Ludwieg Tunnel Mode, high total temperatures by operation in Light Isentropic Compression Heating Mode and increasing the range of conditions by building an expansion nozzle for T6.

 A review of the current UK hypersonic aero-thermal facilities will be undertaken. This will span academia, defence and industry facilities and will compare to international capability. The output will be on recommendations on where the UK should invest in future facilities.

**WP2: Establishment of a UK Hypersonics Network**

The establishment of a centre of excellence in hypersonics at Oxford, and the research detailed above, will have a significant impact on the UK’s capability for building hypersonic vehicles. However, there remains great need for a much broader and concerted domestic effort to make UK hypersonic vehicles a reality. The development of hypersonic vehicles requires direct coupling of structures, aerodynamics, propulsion and thermal management collaboration, and expertise is needed from many different disciplines, while a spectrum of knowledge and understanding from fundamental to applied science is essential.

As part of the fellowship and the collaboration with DSTL, a UK academic hypersonics network will be established with input from industry and defence. This will consist of regular workshops which will be co-ordinated through the Oxford Hypersonic Centre of Excellence. To move the group beyond seminars and discussion groups and to focus the energies of the network into a true collaboration with a joint research proposal.

**WP3: Hypersonic Shock Separation Experiment**

Due to the conversion of the kinetic energy of the hypersonic vehicle into internal energy in the gas, extremely high temperatures are generated. This leads to high temperature thermochemistry effects, which are closely coupled to the flow (aerodynamics + thermochemistry = aerothermochemistry). This process can heavily influence the aerodynamics and heat transfer of any hypersonic vehicle. Also, it effects the observability of these vehicles, as the hot gas is convected behind the vehicle, leaving a large radiating wake. Although numerical models exist, these are typically over-simplifications of the complex physics and chemistry based on experimental data produced in the 1960s.

Fundamental experiments are required to improve numerical understanding of the thermochemistry, and to understand the interplay between the aerodynamics and heat transfer. The development of the T6 Stalker Tunnel at Oxford has provided unique capability not seen previously in Europe. Working with DSTL, a simple double cone / flared cylinder model which will induce a shock separation will be developed. Experiments will be undertaken in T6 at conditions of interest will be developed to provide validation data to support TTCP WG=TP-5.

**WP4:** Redacted

**Note: No background IP will be used for this work programme.**