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RCloud Tasking Form – Part B: Statement of Requirement (SoR)

Title of Requirement	Redacted Under FOI Exemption - Practical realisation of novel plasma-based optical elements in free space (including mirrors, absorbers and laser pulse compressors)
Requisition No.	RQ0000009953 – PO0000008128
SoR Version	**0.1**

1.	**Statement of Requirements**
1.1	**Summary and Background Information**

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Redacted Under FOI Exemption commencing academic year 2022/2023. The award involves provision of financial support, and joint academic oversight of, a PhD student at the Redacted Under FOI Exemption Redacted Under FOI Exemption for the duration of the studentship. The total value of our contribution would be Redacted Under FOI Exemption plus any expenses incurred by the student (details to be agreed) whilst attending our premises for a minimum of 3 months during the term of the Studentship (4 years). Provision of such support is subject to contract between Redacted Under FOI Exemption Redacted Under FOI Exemption

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Ultra-intense lasers (UIL) generate exquisitely short pulses of light at peak powers in the range 10^{12}-10^{15} W, many orders of magnitude more powerful than those produced by conventional lasers. When focussed, UILs can produce extremely high field intensities. The interaction of radiation with matter at these extreme intensities gives rise to a fascinating range of new phenomena, which arguably could be considered as one of the major frontiers of modern physics. Such lasers represent a truly disruptive, versatile technology with the potential to enable a plethora of novel applications, most of which cannot be realised by any other means. Redacted Under FOI Exemption

One of the many plasma-related applications worth exploring is the use of UIL to generate novel transient atmospheric plasma-based structures that can act as optical components. The attraction of this development is that not only could it enable the manipulation of conventional laser beams at a distance, but such optical elements could be used to overcome the power handling, size, weight and cost limitations of conventional optical elements.

Recent work by Redacted Under FOI Exemption has demonstrated the feasibility of producing plasma mirrors, beam stoppers and most importantly, chirped mirrors and Bragg diffraction gratings by the use of the beat wave of two or three UIL light pulses. Diffraction gratings are an essential component of UILs, where they are used to compress chirped pulses to deliver ultra-high peak output powers. This puts enormous demands on the materials used, limiting both the continued development of UILs of increasing peak power as well as imposing size, weight and cost penalties. Optical elements of UILs are made large to avoid optical damage.

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The studentship will strengthen Redacted Under FOI Exemption developing nascent concepts with wide-ranging Redacted Under FOI Exemption based on novel research which is currently being built up.

The PhD project will establish new relationships with na term projects. It will build important links with the Redacted Under FOI Exemption are setting up a new research activity at Redacted Under FOI Exemption with several defence related groups Redacted with a particular focus on propagation of intense laser pulses in atmosphere Redacted Under FOI Exemption Redacted Under FOI Exemption

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1.2	**Requirement**
	The project(s) will involve experimental and theoretical studies of the formation of transient plasma photonic structures (TPPSs). The student will demonstrate the formation of 1D and 2D TPPSs using two methods: (i) ponderomotively-driven electron grating followed by inertial bunching of ions, and (ii) by ionisation, using 200 fs duration pump pulses. In the first method (i), the ponderomotive force, F_p, associated with the beat wave of a pair of similar intense counter-propagating "pump" pulses ($F_p \propto \omega_0\, a_0$, where ω_0 is the laser frequency and $a_0 \approx 8.55\times$10-10 I[W/cm2]1/2□[□m], the normalised vector potential) drives electrons to create a periodic space charge field, which imparts phase-correlated momenta to ions. The ions then inertially evolve into a 1D ion grating (for one pair of counter-propagating beams) or a 2D array of plasma pillars (for two pairs of beams), after a few picoseconds. The student will also undertake particle-in-cell (PIC) simulations for a range of pump pulse durations, for intensities up to 1016 Wcm-2, and gas densities up to 1/3rd of the critical (plasma) density (chosen to be consistent with the experiments planned). Transversely or obliquely probing the TPPS with femtosecond laser pulses should confirm that it behaves as a transient mirror, a chirped Bragg mirror or a 2D plasma crystal (rods). To guide the experiments, analytical models will be developed and numerical simulations carried out using PIC codes. In the second part of the experiment (ii) we will investigate the nearly instantaneous formation of TPPSs by ionisation, when the field amplitude of the beat waves is just above the ionisation potential. When the pairs of pump beams and a probe cross perpendicularly, a time-dependent plasma photonic structure is created. This will scatter the pump pulses into the probe pulse, leading to its amplification, followed by persistent reflection when the probe has passed due to a remnant TPPS Bragg mirror that should persist for up to 100 ps. Demonstration of these TPPSs will represent an important first step in exploration of a new realm of plasma-based optical devices that can be scaled up for use with ultra-high power lasers.

The scope is broad and involves a diverse range of methods, which will provide a superb training. The student will work in a team, learn to manage their project, plan appropriately and undertake thorough data analysis and interpretation. Results will be compared with theory. Both analytic and numerical theoretical methods will be applied, with the latter mainly based on PIC simulations. Experiments will be undertaken at the Redacted Under FOI Exemption

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	Proposed Payment Plan Progress payment 1: end of PhD Year 1 (date to be confirmed) = [redacted] Progress payment 2: end of PhD Year 2 (date to be confirmed) = [redacted] Progress payment 3: end of PhD Year 3 (date to be confirmed) = [redacted] Progress payment 4: end of PhD Year 4 (date to be confirmed) = [redacted] Submission of Final Thesis (date to be confirmed) = [redacted] **NOTE: Payment will be annually in arrears, and upon satisfactory completion of all deliverables at the end of each PhD Year.** **Additional Definitions** **"PHD Year" A consecutive twelve (12) Month period during the Term, commencing on the date that the Authority formally confirms approval of the student in writing** Redacted Under FOI Exemption [redacted] [redacted]
1.3	**Options or follow on work** *(if none, write 'Not applicable')*
	N/A
1.4	**Contract Management Activities**
	Redacted Under FOI Exemption
1.5	**Health & Safety, Environmental, Social, Ethical, Regulatory or Legislative aspects of the requirement**
	N/A

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1.6	Deliverables & Intellectual Property Rights (IPR)				
Ref.	**Title**	**Due by**	**Format**	**Expected classification** (subject to change)	**What information is r deliverab**
100865 – 9953- Q1	Quarterly Progress and Technical Review	T0+3 Months	Presentation (.pptx)	[redacted]	Redacted Under FOI Exemption [redacted]
100865 – 9953- Q2	Quarterly Progress and Technical Review	T0+6 Months	Presentation (.pptx)	[redacted]	Redacted Under FOI Exemption [redacted]

100865 – 9953- Q3	Quarterly Progress and Technical Review	T0+9 Months	Presentation (.pptx)	[redacted]	Redacted Under FOI Exemption [redacted]
100865 – 9953- Q4	Quarterly Progress and Technical Review	T0+12 Months	Report	[redacted]	Redacted Under FOI Exemption [redacted]
100865 – 9953- Q5	Quarterly Progress and Technical Review	T0+15 Months	Presentation (.pptx)	[redacted]	Redacted Under FOI Exemption [redacted]

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100865 – 9953- Q6	Quarterly Progress and Technical Review	T0+18 Months	Presentation (.pptx)	[redacted]	Redacted Under FOI Exemption [redacted]
100865 – 9953- Q7	Quarterly Progress and Technical Review	T0+21 Months	Presentation (.pptx)	[redacted]	Redacted Under FOI Exemption [redacted]
100865 – 9953- Q8	Quarterly Progress and Technical Review	T0+24 Months	Report	[redacted]	Redacted Under FOI Exemption [redacted]

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100865 – 9953-Q9	Quarterly Progress and Technical Review	T0+27 Months	Presentation (.pptx)	[redacted]	Redacted Under FOI Exemption [redacted]
100865 – 9953-Q10	Quarterly Progress and Technical Review	T0+30Months	Presentation (.pptx)	[redacted]	Redacted Under FOI Exemption [redacted]
100865 – 9953-Q11	Quarterly Progress and Technical Review	T0+33 Months	Presentation (.pptx)	[redacted]	Redacted Under FOI Exemption [redacted]

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100865 – 9953- Q12	Quarterly Progress and Technical Review	T0+36 Months	Report	[redacted]	Redacted Under FOI Exemption [redacted]
100865 – 9953- Q13	Quarterly Progress and Technical Review	T0+39 Months	Presentation (.pptx)	[redacted]	Redacted Under FOI Exemption [redacted]
100865 – 9953- Q14	Quarterly Progress and Technical Review	T0+42 Months	Presentation (.pptx)	[redacted]	Redacted Under FOI Exemption [redacted]

[redacted]

100865 – 9953-Q15	Quarterly Progress and Technical Review	T0+45 Months	Presentation (.pptx)	[redacted]	[redacted]
100865 – 9953-Q16	Quarterly Progress and Technical Review	T0+48 Months	Report	[redacted]	[redacted]
100865-9953 - 1	[redacted]	Within First Year	*Attendance*	[redacted]	[redacted]
100865-9953 -2	[redacted]	Within First Year	*Attendance*	[redacted]	[redacted]

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100865 – 9953 - 3	Introduction to Laser Safety.	Within First Year	*Attendance*		Redacted Under FOI Exemption
100865 – 9953 - 4	Redacted Under FOI Exemption	Within First Year	*Attendance*		Redacted Under FOI Exemption
100865 – 9953 - 5	Redacted Under FOI Exemption	Within Second Year	*Attendance*		Redacted Under FOI Exemption
100865 9953 - 6	Redacted Under FOI Exemption	Within Third and fourth Year	*Attendance*		Redacted Under FOI Exemption

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1.7	**Deliverable Acceptance Criteria**

Deliverable acceptance will be subject to evidence of acceptable progress being made against project objectives to be agreed at the outset of the studentship between the academic and [redacted]

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Throughout the PhD, short reports will be provided to the supervisors every three months, in addition to an annual progress report. [redacted] will also be held with the supervisors and an external assessor. A 1st year PhD conference is organised, where the student will present his/her work. The following year, the student will write a paper draft or submit a paper to a peer-reviewed journal. A poster presentation and an interview with research staff external to the project will also take place. The poster is presented during a one-day conference attended by other postgraduate students and staff. A thesis plan will be presented and the student's progress will be evaluated in a viva including the supervisors, and internal and external research staff.

In addition, regular meetings with the direct supervisors will be held throughout the PhD to ensure good progress of the work. A mentor or mentors will also be assigned to the student from the research group.

For the PhD project, a good understanding of the scope of the subject is expected by the end of the 1st year along with a first design of an experiment and develop skills is using one of the particle-in-cell (PIC) codes used by the group to perform simulations, to plan experiments. The second year will be dedicated to the undertaking at least two major experiments and several minor experiments to calibrate equipment etc. The remainder of the project will focus on analysing data, carrying out a theoretical study and interpreting the results of experiments and simulations.

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	The student will enrol in several Graduate courses run by the Redacted Under FOI Exemption to validate corresponding credits throughout his/her PhD to acquire transferable skills. This will ensure they will not only receive specialist training and knowledge during their degree, but also more general knowledge and skills to give confidence in communication, problem solving, business, proposal writing, working with teams etc. in numerous contexts. Redacted Under FOI Exemption [redacted] Redacted Under FOI Exemption [redacted] [redacted]

2	Evaluation Criteria
2.1	Method Explanation
	Evaluating this based on technical compliance and affordability.
2.2	Technical Evaluation Criteria
	Confirmation that the proposal fully meets the Authority's Statement of Requirement. Pass/Fail
2.3	Commercial Evaluation Criteria
	Tenderer has submitted a commercially compliant bid. Firm priced version submitted within budget of Redacted Under FOI Exemption Pass/Fail Labour rates and price as per single source rates uploaded to R Cloud Pass/Fail Completion of Research Workers Form's Pass/Fail Completion of Statement Relating to Good Standing Pass/Fail Confirm acceptance of R Cloud Version 4 Terms and Conditions Pass/Fail