EOS Ultrafast Laser Single Source

29/07/2022

PCR or DSCPR - PCR

Value – ~£216,170

Have there been any negotiations or approaches to the contractor – if so , when. This is to determine whether the pre or post Brexit regs apply. – Supplier has been approached post Brexit

What is the contract for? - The purchase of a Light Conversion PHAROS-SP 2mJ, measurement kit & safety glasses for Dstl trials and experimentation.

Supply, services or works? Supply

Framework? N/A

What are your reasons for single source. – SSJ below:

SINGLE SOURCE JUSTIFICATION: EOS Ultrafast Laser

v1.0 05 October 2022

References:

Introduction

1. The Dstl Electro-Optic Sensing (EOS) project is investigating generation after next (GAN) optical sensing technologies. As part of the project we are also further developing understating in Electro-Optic (EO) sensor technology vulnerabilities and methods for protecting EO sensors. Therefore, we have a requirement to carry out sensor protection testing against GAN laser systems, specifically against ultrafast lasers which we currently do not have access to and have no test data from. Furthermore, an ultrafast laser system with sufficiently high peak powers can create optical filamentation in air which opens up a whole new area of sensing concepts to explore.

Issue

2. Dstl intends to pursue a single source procurement of the following laboratory asset: PHAROS-SP 2mJ ultrafast laser[1]

3. The PHAROS –SP 2mJ is distributed in the UK by Photonic Solutions. This Single Source Justification (SSJ) details the rationale for this decision in the interests of transparency.

Approved SSJ Criteria

4. In accordance with the Public Contracts Regulations (PCR) 2015, an SSJ must meet one or more of the following approved criteria.

a. Absence of tenders or suitable tenders.
b. Artistic reasons, technical reasons or exclusive rights.
c. Extreme urgency.
d. Research and Development (R&D) goods.
e. Additional purchase or hire of goods.
f. Purchase or hire of goods on commodity markets.
g. Closing down sale or bankrupt stock.
h. Design contests.
i. Repetition of works and services.

5. The Project Technical Authority, Dr Gary Stevens, has assessed that this procurement is compliant with criteria (a), (b) and (d) specified above. A detailed explanation is provided below with *technical reasons* being the main factor in Dstl's considered decision.

[1] PHAROS Femtosecond Lasers - LIGHT CONVERSION

SSJ Rationale

7. **Absence of suitable tenders.** Photonic Solutions are the only supplier of this laser in the UK. Due to the specialised nature of this equipment and the level of technical expertise necessary to manufacture such a laser there are a very limited number of manufacturers. After an extensive search, the only two who had a system with the necessary optical parameters were Light Conversion and Amplitude Laser. Amplitude Laser did not respond to a RFQ.

8. **Artistic reasons, technical reasons or exclusive rights.**

The key technical parameters for this laser are;

- Wavelengths: 1030, 515 and 343nm
- Pulse width: <500 fs, <200 fs strongly desirable
- Pulse repition frequency: Single shot to MHz, must be tunable
- Peak power: > 3 GW

The peak power level of optical power is the key differentiating metric as is critical for laser filamentation generation, non-linear process and glass machining.

Laser filamentation is a highly unusual optical phenomenon, where the laser self focusses in the propagating medium (air in this case). The laser beam, instead of diverging as is expected from normal optical behaviour, instead focusses to a microscopically small filament, and propagates for substantial distances in this peculiar propagation mode. The phenomenon is interesting for defence for a variety of potential applications, and the EOS project has a mandate to understand a number of these defence applications. The key feature of the laser that allows filamentation to occur, is the instantaneous power of the laser in the short pulse. For filamentation to occur in air, the minimum power (known as Critical Power) required for filamentation to occur is ~2GW (http://large.stanford.edu/courses/2011/ph240/nicholson1/). Additionally, with longer pulse lengths approaching 1ns, other phenomena intervene (multiphoton ionisation and avalanche breakdown) which prevent filamentation so the experimental performance will be much better using the shortest pulse available (hence the request for <200fs pulse length). Choosing a longer pulse length risks introducing additional physics which will complicate the ability to understand the key phenomenon.

The Critical Power is the key distinguishing feature. Any laser that does not exceed this, cannot be used for the intended application.

A secondary but important distinguishing feature is the pulse repetition rate. One of the key applications to be explored is long range single photon imaging, at a variety of wavelengths. To realise single photon imaging the laser must be matched with a camera. Available single photon cameras will operate much more effectively with a laser repetition rate of approaching 1MHz.

Furthermore, upon due consideration, the Amplitude laser product does not satisfy some of the key elements of our requirement on the basis that it does not come with an integrated harmonic generator. This is important as it allows for generation of 3 different wavelengths, including in the

UV where we currently have no capability. This also affects the portability of the unit – it is required to be able to move the laser from the lab environment to other labs and the laser range.

Other laser systems were investigated from major manufacturers including NKT Photonics, Menlo Laser, Lumentum and Coherent (see below)

9. **Research and Development (R&D) goods.**

The PHAROS is being procured for R&D. Owning a system will enable Dstl to undertake trials and experimentation independently and without the need to raise supplier contracts to support trials and provide equipment. This is essential for completing the outcomes in the EOS project mandate. Without access to this equipment it is impossible to carry out this research and there are no suitable facilities and equipment elsewhere to carry out this level of testing, especially in consideration to possible classification levels of some of the work in the future.

Market Research

10. Thorough market research was carried out by a survey of other laser products and talking to suppliers. No other product has been found that has that has the same performance as the PHAROS product

a. NKT Origami XPS-5S[2]. Several meetings were held with NKT Photonics who proposed their Origami XPS-5S product. A quote was also provided. This product has the required pulse durations and harmonic generator (although external to the laser) but the max pulse energy was 70uJ with a peak power of 160 MW compared to the 2mJ and 6GW offered by the Pharos. This is a difference in power of nearly 30x. This therefore does not meet the critical power requirement to enable replication of the filamentation phenomenon.
b. A meeting was held with Menlo Systems. Their highest power product was the Orange High Power[3] but that had a pulse energy of 100nJ making it >300x lower in energy than the PHAROS and therefore unsuitable. This therefore does not meet the critical power requirement to enable replication of the filamentation phenomenon.
c. The Lumentum Femtoblade[4] was evaluated. This is the highest energy laser Lumentum (one of the major laser manufacturers in the world) produces. The laser is close in performance to the PHAROS but the peak power is 0.6 GW. The pulse repetition frequency is not tunable and only a single wavelength can be selected at manufacture as opposed to the PHAROS which can utilise all 3. This therefore does not meet the critical power requirement to enable replication of the filamentation phenomenon.
d. The Coherent Mocano[5] also has the same issue in that it can only be selected with a single wavelength. This therefore does not meet the critical power requirement to enable replication of the filamentation phenomenon.

[2] ORIGAMI XP - UV harmonic 3 port - NKT Photonics
[3] Femtosecond Ytterbium Laser | Menlo Systems
[4] FemtoBlade Femtosecond Micromachining Laser (lumentum.com)
[5] Monaco - Industrial-Grade Femtosecond Lasers | Coherent

e. The Amplitude Magma 5[6] is the closest in performance to the PHAROS and does produce sufficient peak power. The disadvantage of this product is the harmonic generator is a separate unit as opposed to being integrated within the laser as with the PHAROS. Amplitude have also not responded to our RFQ. The pulse repetition frequency is also limited to < 300 Hz and whilst the pulse width is <500 fs the PHAROS is <170 fs which is desirable. The pulse repetition frequency of <300Hz is entirely inadequate for single photon imaging.

Summary

11. This SSJ has demonstrated that a single source procurement is the only appropriate option in this instance. Links to original equipment manufacturer (OEM) product data sheets clearly show the specification differences between the PHAROS product and that of other potential suppliers. It is to the best of our knowledge the only system that meets our required and desirable specifications and outperforms the next best option (which due to its low repetition rate also excludes exploring a key imaging application) for which we have not received a quotation.

[6] Magma_ref-g_HD.pdf (amplitude-laser.com)