HEDP Report Apr 01

National Nuclear Security Administration

Appendix G – United Kingdom Statement on High Energy Density Physics

The Role and Strategy for the Provision of High Energy-Density Physics Experimental Facilities in Support of the UK Research and Capability Maintenance Programme*

G.1 Introduction

1. The overarching objective of the UK nuclear warhead programme is to keep the Trident warhead in service, and to be able to underwrite its performance and safety over a period much longer than its originally intended service life. During this time components within the warhead will undergo aging processes, many of which are poorly understood, and some components may be replaced in refurbishment programmes. It is essential that the performance and safety of the warhead can continue to be underwritten under these circumstances. In addition, the UK is to retain the capability to design, manufacture and underwrite the performance of a successor warhead for the longer term should one be required. All of this is to be achieved without recourse to underground nuclear testing. 25yrs

2. With the advent of the Comprehensive Test Ban Treaty (CTBT), the UK, in common with other nuclear weapon states, is developing science based stockpile stewardship (SBSS) programmes to enable us to continue to underwrite the performance and safety of nuclear warheads without underground nuclear tests. The programmes include the development of improved theoretical models, the exploitation of supercomputer technology and AGEX I (hydrodynamics, typically in support of primary physics) and AGEX II (high energy-density physics, typically in support of secondary physics) programmes aimed at providing data to underpin the modeling.

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G.2 The Role of AGEX II

3. The AGEX II experimental programme provides vital element of the overall UK stockpile stewardship programme in three crucial areas:

   a) Provision of experimental data. It is essential that the improved theoretical models of warhead behaviour be underpinned by high quality data on material opacity and equation of state at relevant temperatures and pressures. In addition the models must be validated against experiments which enable dynamic problems in radiation-hydrodynamics to be studied in representative geometries.

b) Recruitment, retention and development of high calibre staff. If the long-term UK objectives are to be met, the programme must have continuing access to scientific and engineering staff of the highest calibre. In order to achieve this objective the programme must offer relevant areas of challenging work and the necessary facilities to attract and retain such staff. The plasma physics work in AGEX II is regarded as a particularly suitable area. Much of the work will be publishable in the scientific literature. Good work here will enhance the reputation of AWE in the wider technical community, encourage the flow of ideas into and out of AWE and ultimately have a beneficial effect on recruitment and retention.

c) US/UK collaboration. For many years the UK has benefited enormously from close technical dialogue with the US in the nuclear warhead area. This has given the UK access to a range of facilities (including in the past underground test facilities) and exposure to a more extensive scientific programme and database. In return we understand that the US values the independent view that a small but traditionally innovative UK programme offers. The US SBSS AGEX II programme includes a number of facilities in which high-power lasers and pulsed power machines are to be used for the generation of high temperatures and pressures. NIF is to be the cornerstone of the programme. It is vital that the UK carries out a programme of work, both independently and collaboratively, which will enable us to contribute to joint US/UK objectives and access the much larger US programme in this area. In order to do this the UK must have both a programme of work, and the high calibre staff, which will enable us to remain a credible partner in this vital relationship.

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G.3 Programme Balance

4. The research and capability maintenance programme must be constructed in such a manner that there is a realistic programme work across the whole field of the development of theoretical models, exploitation of supercomputers and the underpinning hydrodynamic and plasma-physics experiments, which is directed towards the long-term objectives. The programmes must be balanced so that meaningful work can be done in a coherent way in all of the programme elements, but at the same time fitting within the available resource constraints including the ongoing maintenance of our production facilities. It is clear that for a warhead capability there must be substantial work and investment in each of the areas. Because of the limited budget, however, hard choices have had to be made on the balance of investment between programme elements.

5. A supercomputer capability which will enable AWE staff to make significant advances in modeling and to make a useful contribution to US/UK objectives will be essential. It is not possible to fund systems comparable with leading-edge ACSI technology, but the level of investment planned should enable the UK to follow US developments, albeit some years behind.

6. An indigenous AGEX I capability is essential and has traditionally been a UK strength area. A new hydrodynamic research facility (HRF) is planned for the middle of this decade. The facility will enable experiments to be fired more efficiently and will be equipped with high resolution, multi-axis diagnostics.

7. The UK must have access to high energy-density AGEX II facilities. The full 600TW power of NIF will be needed to study thermonuclear processes. At lower powers of order 100TW it will be possible to measure complex warhead processes using sophisticated scaled geometries, with supporting research carried out at still lower powers. The UK has decided that it is not affordable to build an indigenous facility of even 100TW magnitude and had decided to enter into partnership with the US to permit UK access to NIF. It is essential that the UK is able to undertake a programme that will allow it to carry out the necessary national programmes whilst remaining a credible partner for collaboration.

G.4 The Way Ahead for High Energy-Density Experiments

8. The initial plans for UK investment in NIF supported a shot rate enhancement programme (SREP) to increase the capacity of NIF to make headroom for UK experiments, provided at a later date a second target chamber for UK experiments up to 100TW and permitted occasional access to the full NIF. However increased costs and programmatic delays for NIF mean that consideration of a second target chamber is now beyond planning horizons.

9. The UK, in discussion with the US, now plans to continue with the SREP investment in return for access to NIF (formalised in a letter of 15 Nov 2000 from DOE/DP1 to the UK MOD's Chief Scientific Advisor). However to supplement access to NIF, which is now later and our investment buys us less access than originally planned, consideration is being given to identifying other facilities which the UK might use. These include OMEGA in Rochester and LIL in France. HELEN will be retained for the time being and consideration is being given as to whether modest upgrades might be a worthwhile investment.

10. In addition to the laser technology the UK has watched with interest the potential of pulse power Z at Sandia, as an AGEX II tool. This technology is evolving and appears to be making significant progress and the UK would wish to make use of it, working collaboratively with partners in the US nuclear weapon laboratories.

G.5 Conclusion

11. The UK regards experimental work on high energy density physics as essential for a comprehensive stockpile stewardship programme. Funding constraints mean that the UK will have to include access to offshore facilities, principally NIF in its strategy for stewardship of our stockpile and maintenance of capability.

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