# Orion
## Progress Update

The Orion project is now well into the third year of the delivery phase. As well as the construction of the building itself, which is obvious to all on the Aldermaston site, excellent progress is being made on the installed laser equipment, target area systems and the associated engineering which will enable Orion to generate the extreme conditions required to drive the plasma physics programme forward. In particular, prototyping of critical components and sub-systems is underway, the pulse power system is in production at Thales in France, much of Orion's laser glass has already been delivered and fabrication of the target chamber is well advanced at Stadco in the U.S.

### Laser "front end" prototyping

Each of Orion's long or short pulse laser beams derives from one of two optical pulse generators (OPG1 & 2) which feed nano-Joule level pulses to the pre-amplifier modules (PAMs) where they areamplified to the 10s of mJ level before injection into the large aperture, multi-pass disc amplifiers.

The ultimate reliability of Orion will depend on the performance of these "front end" systems. Designed in-house, based largely on systems proven on HELEN, they are being prototyped and tested on the AWE site before final assembly in the Orion building. This approach will enable operating characteristics and long term performance of each module to be determined precisely, well in advance of when they are needed for the commissioning of the Orion laser beamlines. This will simplify final installation and avoid delay during the commissioning phase while the operational experience gained will enhance the productivity of Orion in the early part of the operational phase.

The long-pulse generator (OPG1) slices pulses from a continuous wave laser, producing low-energy pulses with a temporal profile which can be tailored to the requirements of individual experiments. The system is based on high stability fibre-optic components, resulting in a very low-maintenance system. OPG1 has been fully prototyped and a variety of pulse-shapes already demonstrated. In the next stage of prototyping, this output will be fed via a fibre-optic to the PAM, where the energy will be boosted by a factor of $10^{12}$, the beam spatially smoothed and the spectral profile modified to produce a smooth profile on target.

The prototyping is proceeding according to plan and excellent results have been obtained to date. It is anticipated that this work will be complete early in 2008.

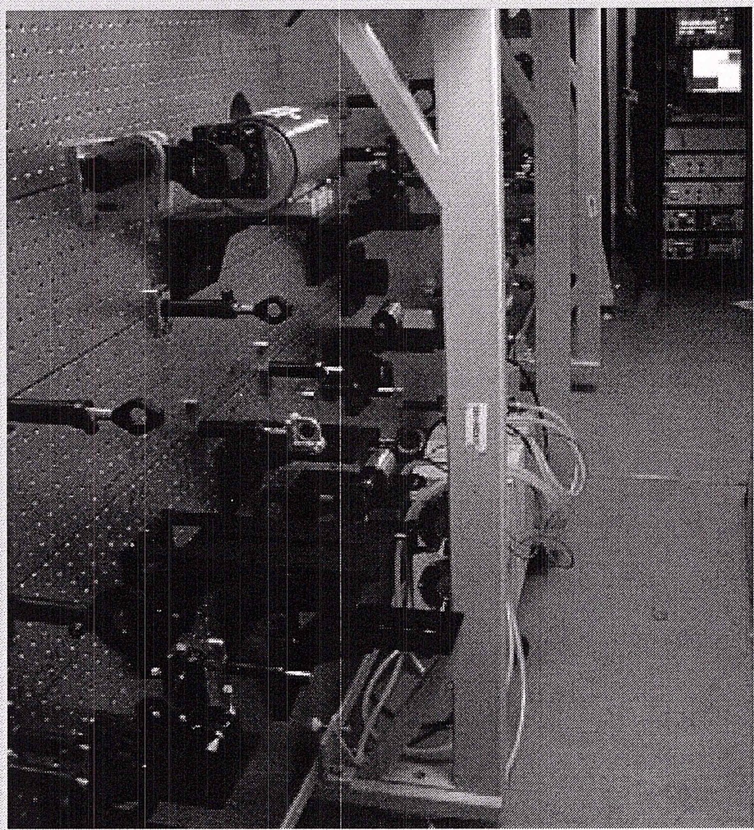
## Pulse Power System

The optical amplification of each of Orion's long and short pulse laser beams to the 500 Joule level is accomplished by passing the beams through neodymium doped glass slabs which have been pumped to an excited energy state by pulsed flashlamps which surround them. This process is relatively inefficient (~ 0.1%) and to obtain the full energy output from Orion, 7 Mega Joules of energy must be delivered to the flashlamps. This energy is derived from capacitor banks, charged to a maximum of 25 kV, which are discharged by spark gap switches through pulse forming inductors and co-axial cables to the flashlamps.

The pulse power system is being designed and manufactured under contract by Thales Communications, France and will take the form of fifteen individual modules, each with an electronic interface which will communicate with the Orion control system. This modular approach will allow individual beamline amplifiers to be pumped to different levels, enabling the energy balance between beams to be accurately controlled.

Following the final design review in January 2007, two pre-production modules have been manufactured for performance and life testing. The first completed module will be delivered to the project in October 2007, with completion of the contract scheduled for December 2008.

Figure 1

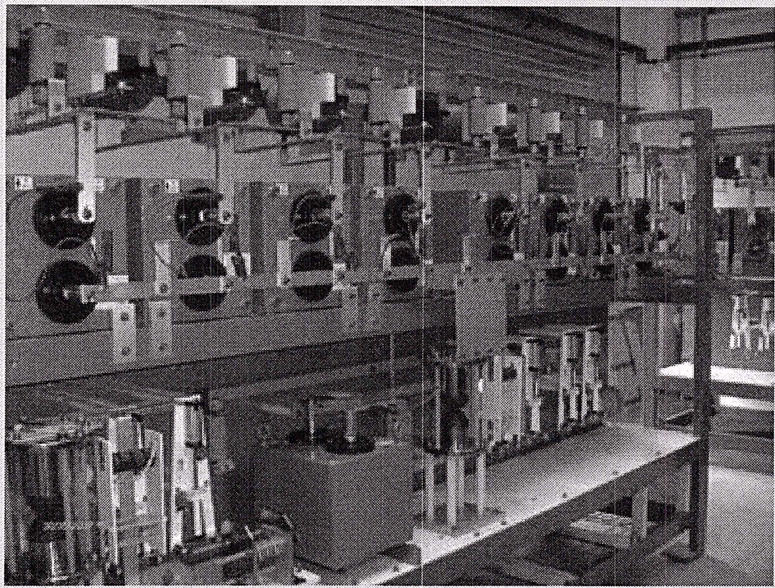


Laser pre-amplifier module (PAM) under test

## Laser glass

The contract for the supply of neodymium-doped glass laser slabs was one of the first large procurement actions undertaken by the Orion project. These slabs are fundamental to the operation of the laser, responsible for amplification of the optical pulses from the pre-amplifiers (see above) to the final output energy of 500 J per beam. Orion has been fortunate in securing access to surplus laser glass originally intended for the National Ignition Facility (NIF) under construction for the

Figure 2



Pre-production capacitor bank module under construction at Thales Communications, France

U.S. Department of Energy at Lawrence Livermore National Laboratory in California. For use in Orion, the NIF material must be cut to size, clad with absorbing glass around the periphery to prevent parasitic oscillations, and then polished to a flatness measured in terms of a fraction of the wavelength of light. This work is being undertaken by the Zygo Corporation.

Figure 3 shows one of the largest size of laser disc needed for Orion being inspected for surface defects. In all some 158 such slabs are required, including spares for the commissioning phase and subsequent facility operations; 108 have already been received with completion of the order scheduled for December 2007.

## Orion target chamber manufacture

Orion's aluminium target chamber will be four metres in diameter and weigh over six tonnes. It will have twelve laser beam entrance ports and a further 120 penetrations for diagnostics.

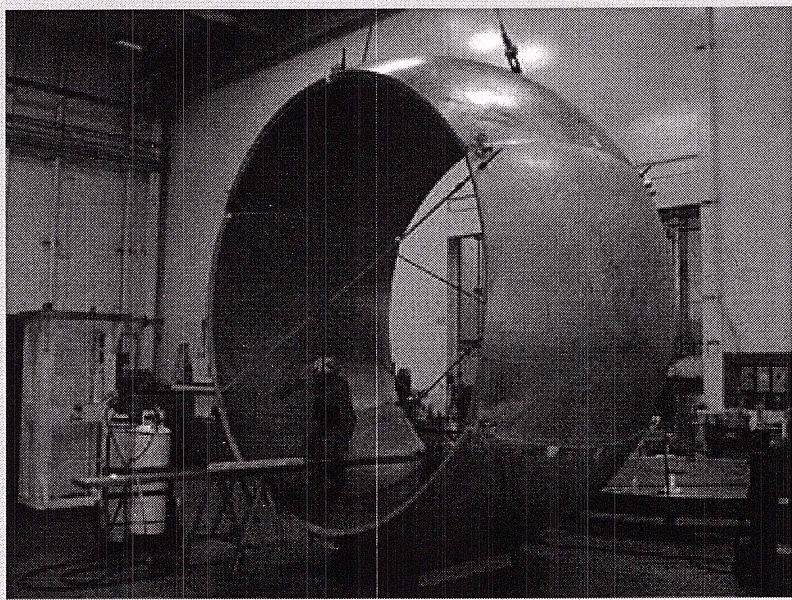
The contract for the chamber was placed in May 2006 with Stadco Inc. in California. Following completion of the Final Design Review in November 2006, fabrication commenced. The chamber is being manufactured in three sections; two end domes and a central ring (shown in figure 4). When manufacturing is complete, the vessel will be assembled, tested for vacuum performance and dismantled

Figure 3

Inspection of the first batch of Orion laser glass (Photo courtesy of Zygo Corporation) for shipment to the UK in February 2008.

Orion project team members make regular visits to the company to measure progress with the contract against the baseline schedule and to witness key performance tests, particularly on the quality of the welded seams. The delivery time of the target chamber is particularly important to the project as installation and commissioning of the chamber are key milestones of the overall project schedule.

Figure 4



Orion target chamber in manufacture at Stadco Inc. in California

## Orion construction

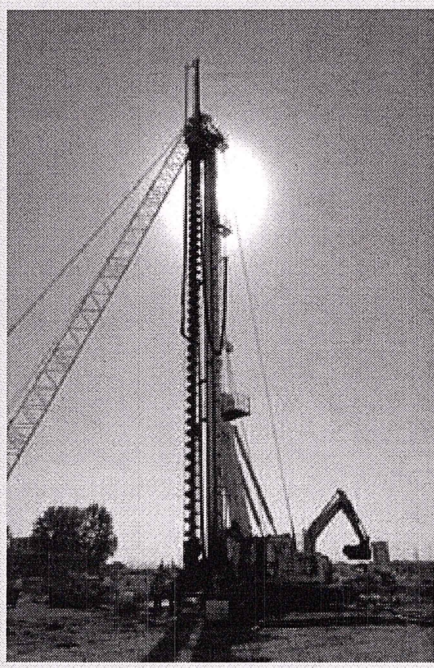
In the north west corner of the Aldermaston site, Orion is rapidly becoming a familiar AWE landmark. 100 metres long, sixty metres wide and over twenty metres high, the facility building will provide a safe, modern working environment for this world-leading facility for the next twenty-five years.

Orion laser beams will be pointed and focused with sub-micro-radian accuracy to achieve the required conditions in the target. To enable this, the building must provide an ultra-stable platform which isolates the laser and target chamber from the effects of ground vibration, traffic noise and effects of the weather. To achieve this, the building steelwork is supported on a system of sleeved piles, isolated from the foundations of the laser hall and target chamber.

Following the piling operation on site, the vibration behaviour of each pile was measured individually and checked against the specification to ensure that the completed structure would perform as required.

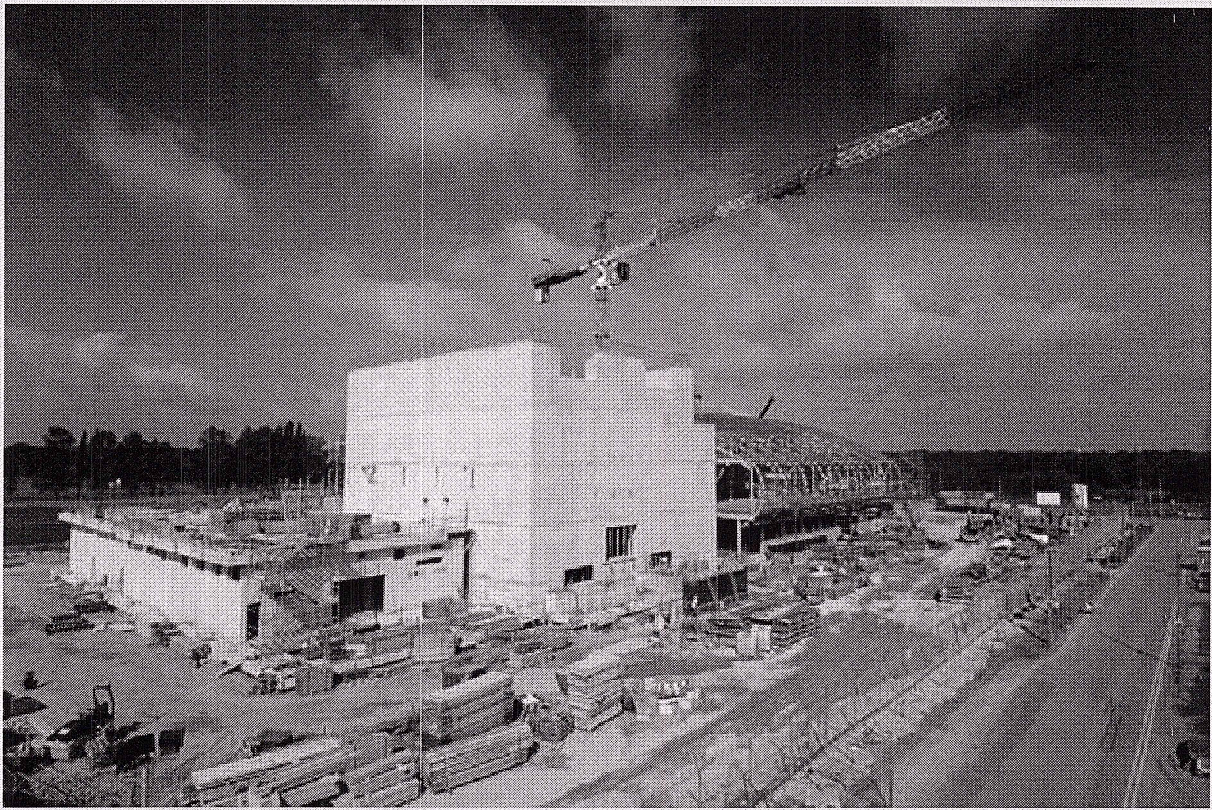
Casting of the 1.5 metre thick reinforced concrete shield walls of the target hall was completed in May 2007; the scaffolding was removed and the area prepared for installation of the roof beams. The shield is designed to enable 500 full energy, high radiation yield laser shots to be taken each year whilst limiting the external dose to below the level of natural background radiation.

Figure 5



Sinking of over 300 piles, up to 30 metres deep, commenced in August 2006

Figure 6



May 2007, the final stages of casting the concrete shield wall for Orion's target hall

The graceful sweep of Orion's curved roof is functional as well as aesthetic. It follows the form of installed equipment and offers security advantages over the more traditional buildings on site.

The result is a design which befits one of the most exciting research facilities ever to be constructed in the UK.

Construction progress is very encouraging. The building will be weathertight by the end of September with completion at the end December 2007.

## The future

Following handover of the Orion building to the installed equipment team in January 2008, installation of the laser equipment will commence. By 2009, we will be ready for the commissioning and proving of all the equipment, with delivery of beam to target at the end of the project in December 2010.

Then AWE's scientists and engineers, the academic community and the MoD customer, will work to ensure that Orion takes its rightful place as a world-leading experimental facility, strengthening the UK capability in the deterrent programme, making a unique contribution to the understanding of high energy density physics and opening up new areas of scientific exploration.