NOVA/BEAMLET/NIF UPDATES JANUARY–MARCH 1998

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Nova Operations

Nova Operations performed 200 full system shots resulting in 208 experiments during this quarter. These experiments supported efforts in ICF, Defense Sciences, university collaborations, laser science, and Nova facility maintenance. As the technicians hired during the previous quarter gained experience in operating the laser, we were able to begin expanding the shift schedule. In the middle of the quarter, the second shift was moved to end at 10:30 p.m. During the next quarter, the operation of Nova will expand back to a full two shifts per day, with the second shift ending at 12:30 a.m.

During this quarter, 94-cm full-aperture gratings were installed in the Petawatt laser system. This allowed an increase in beam diameter to 55 cm, with a corresponding maximum energy of ~900 J. With the completion of the full-aperture compression system, activation of an adaptive-optic wavefront correction system began. Experiments in the Petawatt front-end demonstrated the ability of the deformable mirror to correct for several waves of distortion in a reproducible fashion. Hartmann sensor packages were then deployed in the Nova Output sensor and in the Petawatt diagnostic station following compression. An automatic component status verification system was deployed on the Petawatt system at this time to ensure the proper configuration of components before a full-system shot with the deformable mirror.

A newly redesigned system was built to retrofit one beamline of Nova with an $f/8$ final focus lens for experiments designed to estimate the backscatter levels in NIF hohlraum targets. These experiments during the next quarter will give us confidence that there will be no surprises in NIF hohlraum backscatter levels with reasonable amounts of bandwidth from a high-frequency modulator in conjunction with kinoform phase plates. The experiments will also investigate the effect of a polarization smoothing technique on backscatter levels from various types of targets.

Beamlet Operations

Beamlet completed a total of 121 shots in 44 shot days this quarter. We performed major campaigns on final optics damage at 5 J/cm^2 at 3ω, evaluated extensively the NIF first-boule doubling crystal, executed the final series of pinhole closure experiments at high energy and long pulse, and measured pinhole closure and propagation effects of 1D smoothing by spectral dispersion (1D-SSD). We also began experiments to determine doubling efficiency of the first large fast-growth KDP crystal. Beamlet operations and experimental campaigns are detailed as follows:

- The final optics cell (FOC) and integrated optics module (IOM) were assembled in late December and installed in the Test Mule just before the end of the year. Following alignment, calibration, and the first 5 ramp-up shots, we vented and inspected the medium damage threshold final focus lens (MDT-RFL). We inspected once more the MDT-RFL following the first two shots at the desired fluence (5 J/cm^2), then proceeded with the shot series (see Figure 1). A special optics inspection mechanism was developed for inspecting the MDT-RFL mounted in the Test Mule.
- Eleven shots at 5 kJ (5 J/cm^2) were performed, followed by another Test Mule vent and lens inspection that revealed growing damage as was observed using the on-line inspection system (Schlieren On-Line Imaging of Damage) and by high-resolution near-field photographic film images. Eight more shots were done, and then the IOM/FOC was removed for disassembly, inspection, and damage mapping.
- A new frequency doubler, cut from the NIF first-bundle boule, was delivered to LLNL the last week of December. It was coated, characterized, and installed in the second FOC (FOC-B) by the week of January 26, 1998. The MDT lens, from the

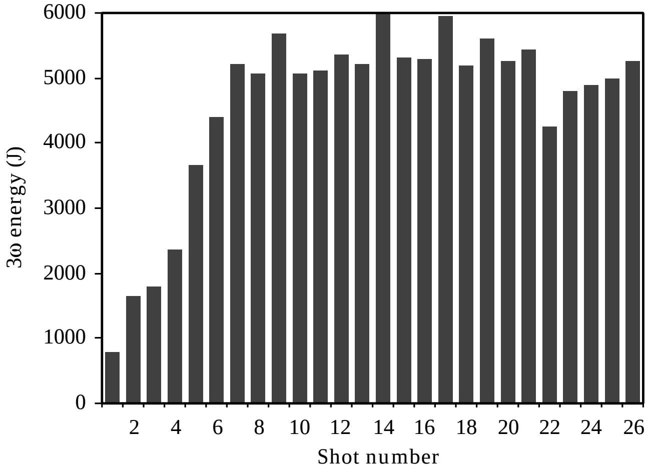

FIGURE 1. Beamlet MDT Lens Campaign, January 1998. (50-00-1098-1955pb01)

above damage tests, was installed in FOC-B, and the IOM/FOC assembly was returned to Beamlet in late January for Test Mule installation and alignment. System shots for the Doubler Only campaign commenced at the end of January and continued through the end of February.

- Significant calibration effort was performed to obtain confidence in the doubler efficiency experimental results. The design of the focal plane diagnostics (FPDs) does not allow for a direct measurement of all three wavelengths; instead the 2ω is inferred by subtracting a measurement of the 1ω from the whole-beam calorimeter. In addition, the large FPD attenuation precludes direct calibration, and there were unresolved stray light problems affecting the energy diodes. To circumvent this, a large plate of BG18 (1ω-blocking) filter glass was installed to obtain absolute 2ω measurement of the whole-beam calorimeter from which we scaled all of the Doubler Only experiments. This data linked all the previous measurements to the absolute frequency-doubling conversion efficiency of 73.2% for the whole beam, temporal and spatial variations included. This compared to 72.9% from the plane wave model, accounting for the measured pulse shapes. Following these experiments, the diagnostics were redesigned similar to the Beamlet Phase I system, using prisms and calorimeters to separate and independently measure energy in each of the three colors.
- Hardware design is under way for the French Commissariat à l'Energie Atomique experiments scheduled for June. The experiments include silica plate filamentation experiments at 3ω, full-aperture polarizer damage testing, and high-fluence 1ω mirror damage testing at reduced aperture.
- The final pinhole closure experiments, 20 shots, were conducted during the month of March, including cone-shaped 100-μrad Ta, 100-μrad stainless steel (SS), 100-μrad diamond-oriented gold-plated SS, and a 100-μrad solid Au pinhole. Of course, we still had the 150-μrad SS cone, which has been the workhorse for some time because of its superior back-reflection (none) and closure characteristics. In addition, we tested the French pinhole—a design similar to two short cones in series. The Ta cone pinhole performed the best. It took over 7 kJ in a 20-ns square pulse to close it, and it stayed open up to 11 kJ in a Haan ignition pulse with the nominal SSD. The diagnostics for closure worked very well, with good returns from the streaked pinhole interferometer and the gated optical imager. Data analysis was greatly improved with the addition of numerous Interface Definition Language routines to automatically calculate the contrast ratio for a number of 5- × 5-cm patches for each shot. We also measured the threshold for pinhole closure with background pressure, taking shots up to 3.5 kJ through the 100-μrad cone at 90 mT.
- 1D-SSD experiments were purposely limited to a demonstration of transmission through two different pinholes. Two shots above 15 kJ (15.1 and 15.4) were taken through the 150-μrad pinhole with ±7.5 μrad of 1D-SSD using the Haan ignition pulse. Evidence of pinhole closure initiation was observed on the pinhole interferometer, but the plasma was far enough out of the beam focus to not cause near-field beam modulation. We also propagated 20-ns square and Haan ignition pulses through the 100-μrad Ta cone. The Ta cone was the big surprise in the campaign, as it performed exceedingly well. It transmitted 11 kJ using ±7.5-μrad divergence with the Haan ignition pulse shape. The last mirror in the mirror tower (M9), damaged during the first 11-kJ Haan ignition pulse shape, incurred a damage spot of about 3 mm and was subsequently replaced. Although the spot is not growing, the modulation is too large for further high-fluence frequency conversion campaigns.

National Ignition Facility

Summary

Overall progress on the NIF Project remains satisfactory for the second quarter of FY98. During this quarter, NIF construction subcontractors recovered four of the estimated six to eight weeks of schedule lost in the November and December El Niño rains, despite the heaviest rainfall on record for the month of February. Implementation of a wet weather construction plan,

additional construction equipment, additional manpower, and an extended workweek combined with a second shift generated a sense of urgency and improved productivity through the quarter.

In Special Equipment, 79% of the Mid-Title II (65%) design reviews and 10% of the Title II (100%) final design reviews have been completed. The two major procurements, Beam Transport Stainless Steel and the Target Chamber, are on schedule.

In Optics, the progress on facilitization contracts and development activities remains satisfactory. The first full-scale continuous pour of NIF laser glass has yielded positive results. The potassium dihydrogen phosphate (KDP) rapid growth decision was made early, and the KDP facilitization contracts awarded. Also, the contracts for mirror and polarizer coating facilitization were awarded.

There were no Level 0, 1, 2, 3 milestones due during the second quarter. There were 18 Department of Energy / Oakland (DOE / OAK) Performance Measurement Milestones due this quarter, and 19 were accomplished. There was a total of 30 milestones due in the first half of FY98, and 31 have been accomplished, for an overall variance of (–1). In March, nine milestones were completed, whereas seven were planned. This is based upon DOE / OAK's concurrence with *Revision A* of the FY98 Milestones, which was effective February 28, 1998.

Key Assurance activities during the second quarter to support the Project included assurances preparation for major concrete pours and disposition of mammoth bones. Litigation activities included the following:

- Litigation support to the DOE for the settlement of 60(b) (Agreement to prepare a Progammatic Environmental Impact Study supplement analysis and to conduct specific evaluations and surveillance of potential buried hazardous materials) and the overall litigation against the Stockpile Stewardship Program's *Programmatic Environmental Impact Statement*.
- The NIF Construction Safety Program.
- Interface with the LLNL Institutional surveillance for buried hazardous / toxic and / or radioactive materials.
- Risk Management Plans.
- The *Final Safety Analysis Report*.
- Assurance surveillances and audits.
- Support for environmental permits.

All are on schedule.

The current assessment of Project status remains as stated last quarter; there will be no change to the 4th Qtr. 2001 Level 2 milestone for the End of Conventional Construction nor to the 4th Qtr. 2003 Project Completion date. However, it is still anticipated that there could be a three- to six-week impact to the 4th Qtr. 2001 Level 4 milestone for the start-up of the First Bundle. The current assessment is that there may also remain two to four weeks' impact to other internal milestones for construction. This is an improvement since the first quarter report resulting from the accelerated use of overtime on the construction site. Accelerated activities in addition to the rain mitigation actions taken in the second quarter, which could reduce the First Bundle schedule impact, are currently being assessed in conjunction with construction contractors.

Site and Conventional Facilities

The NIF Conventional Facilities construction subcontractors recovered four weeks of lost schedule during the second quarter despite the heaviest rainfall on record for the month of February. At the end of March, Walsh Pacific (Construction Subcontract Package [CSP]-3, Target Building Mat and Laser Bay Foundations) had recovered one-half of the two months schedule lost in the November and December El Niño rains. As noted above, implementation of a wet weather construction plan, additional construction equipment, additional manpower, and an extended workweek combined with a second shift generated a sense of urgency and improved productivity through the quarter (see Figure 2).

The bids for CSP-6 / 10, Target Area Building Shell and Buildout, were received in March, bringing to closure the procurement phase of the major Conventional Facilities construction subcontracts. Seven of the eight Conventional Facilities construction subcontracts have been awarded; two of these subcontracts (CSP-1 and 2) are complete, and four subcontractors (CSP-3, 4, 5, and 9) are actively constructing on the NIF site. Construction work in place at the end of the second quarter is approximately 9%.

The Conventional Facilities Title II engineering design ended on schedule in February, and Title III engineering support to construction began in earnest concurrent with the ramp-up of subcontractors and craftspersons at the NIF site.

FIGURE 2. Target Area retaining wall forms and rebar. (40-60-0198-0084#46pb02)

Construction Milestones. Several important milestones were achieved on the NIF site in the second quarter. The critical path backfill of the retaining wall along gridline 10 / 12 was completed (FY98 DOE / OAK Performance Measurement Milestone). This was important for two reasons. First, the completion of backfill allowed footings and tie-beams in the Laser Bays to be completed, a prerequisite to start of structural steel erection, which is, in turn, on the critical path of construction activities for the Laser Bay. Second, the completion of the Target Building retaining wall backfill was the final construction work by Teichert under CSP-2.

Another significant milestone achieved by Walsh Pacific (CSP-3) was the placement of the Target Bay mat slab (FY98 DOE / OAK Performance Measurement Milestone); this 3300-cubic-yard continuous pour occurred over an 18-hour period in late March (see Figure 3). This critical path concrete work in the Target Building is the first of three major mat slab pours by Walsh Pacific that are prerequisite to the start of work in the Target Building by Nielsen-Dillingham, CSP-6 / 10. Other work completed by Walsh Pacific included forming, rebar, installation, and placement of concrete in the Target Building retaining wall and footings; the Target Building wing walls; and the footings, short pilasters, and tie beams within the Laser Building core.

Nielsen-Dillingham (CSP-4) continued steel fabrication in Oklahoma City during the second quarter, with anticipated arrival on site in mid-April. All critical submittals and shop drawings have been reviewed and approved. Dillingham (CSP-5) also completed the Optics Assembly Building (OAB) concrete footings six days ahead of schedule (FY98 DOE / OAK Performance Measurement Milestone). The work on contract includes: completed footing and foundations, poured basement walls, continued installation of the grounding loop for building steel, erected structural steel column stubs on the entire perimeter, and started basement wall. The Nielsen-Dillingham CSP-6 / 10 bids were opened and the contract was awarded in March.

FIGURE 3. Finishing the Target Bay slab. (40-60-0398-0616#20pb01)

Hensel-Phelps (CSP-9) and their subcontractors have fully mobilized their trailers on site. A full platform proposal that will shorten the subcontractor’s duration in the Laser Building was negotiated this quarter at no cost to the NIF Project. Hensel Phelps will begin site utilities in April, including: storm drain and sewer lines at the east side of the site, tie into mechanical bundle at the northeast side of the site, and site temporary power.

Mammoth Bones. The excavation of the mammoth bones in the area of the Laser Building 1 retaining wall footing, adjacent to Switchyard 1, was completed in February. DOE confirmed in March that bones located adjacent to the Diagnostics Building and Switchyard 2, outside the building footprint, will not be removed at this time. Change orders will be issued to subcontractors by Conventional Facilities to protect the bones for future recovery. Survey information and maps identifying the locations of the bones have been recorded for future reference.

Special Equipment

This quarter, a major focus was to successfully bring closure to outstanding requirement issues as part of the Mid-Title II (65%) design reviews. With the completion of the second quarter, a majority of the Mid-Title II design reviews were completed, and more of the final (100%) design reviews were held. Reviews of the Beam Transport procurement packages also began.

Mid-Title II reviews were held for the Laser Amplifier, the Target Positioner, the Optical Pulse Generation (OPG), Optical Assembly and Alignment Systems, Alignment Control, Precision Diagnostics, Roving Mirror and Roving Assemblies, Power Diagnostic and Back-reflection Sensor / Portable Sensor, Energy Diagnostic, the Final Optics Assembly (FOA), the Target Chamber Vacuum System, Target Area Structures, and Relay Optics / 3ω Energy. Final design reviews were held for the Supervisory Control (Framework) and the Computer Systems. Design review reports were prepared and released for the Pockels Cells, the Beam Transport, the Target Positioner, the Amplifier, the OPG, and the OAB reviews.

Laser Systems. Nearly all Laser Systems design issues have been resolved, and detailed drawings are being produced in all areas. Substantial progress was made on prototypes during the second quarter. The preamplifier prototype was procured and assembled in preparation for testing during the third quarter. Tests on the Amplifier Module Prototype Laboratory (AMPLAB) amplifier prototype were completed for the 2-slab-long configurations. The 4×1 Pockels cell prototype was assembled and tested, demonstrating the necessary switching performance for the NIF. The detailed design of the power conditioning first-article prototype was completed, while the performance models were validated by tests on the existing prototype capacitor module. Design documentation is being produced at a rapid pace consistent with completing in time to procure hardware for the first beam bundle.

Optical Pulse Generation. A substantial effort during the past quarter focused on resolving the remaining issues required to complete the OPG design. Experiments and modeling quantified the modulation due to FM-to-AM conversion from the modulators in the Master Oscillator system. A decision was made to use polarizing fiber to minimize the modulation, while system propagation modeling began to quantify the impact of the residual AM on laser performance. The rmaining hardware for the prototype preamplifier module arrived, and assembly of this complex subsystem began. Perfor-mance of important subassemblies was validated, in-cluding commercial diode arrays, the regenerative amplifier, and the optoelectro-mechanical beam-shaping module produced by Allied Signal in Kansas City. Optical design of the preamplifier beam transport system was completed, enabling the team to freeze the design and begin detailed drawing production.

Amplifier. Since the key features of the amplifier design were frozen in the first quarter, the design team is now in the process of creating detailed fabrication drawings. During the second quarter, many of the computer-aided design (CAD) models were sufficiently completed that they could be exported to a subcontractor for detailing.

A parallel experimental effort, centered in the AMPLAB, worked to address the few remaining open issues and provide a final physics validation of the design. The $4 \times 2 \times 2$ AMPLAB gain and wavefront experiments were completed during the second quarter, and the facility is currently being configured to measure three-slab-long gain and wavefront to complete the data set required to validate the amplifier model. The three-slab-long measurement is expected to show that most of the wavefront error is produced by the end slabs in the amplifier chain. This would explain the concern raised earlier this quarter regarding a discrepancy between the expected and measured wavefront error on the AMPLAB. Analysis of the data is ongoing, but so far indicates that the amplifier will meet or exceed its gain requirement.

In response to the issue raised earlier this quarter, the cleanliness tiger-team, consisting of NIF amplifier, cleanliness, and optics personnel as well as LLNL analytical chemists, continued to characterize the nature, source, and effects of the contamination observed in AMPLAB. A detailed plan was developed to complete the tests necessary to demonstrate that the amplifier can be installed and operated cleanly.

Pockels Cell. During the past quarter, the plasma electrode Pockels cell (PEPC) detailed design has progressed in parallel with activation and testing of the 4×1 prototype cell. The prototype drawings, also considered the Title II drawings, were entered into the Project Data Management system and placed under configuration control. Several interface control documents (ICDs) were updated to reflect changes since the 65% review. Parts for the prototype control system were ordered. The controls approach will be validated through integrated testing with the 4×1 prototype. The prototype was assembled and tested for the first time during the second quarter. Minor problems with potting and simmering were encountered and solved. By the end of March, the prototype was operating, and simultaneous measurements on all four apertures indicated that the cell exceeds the minimum NIF requirements for switching efficiency in both the “on” and “off” states. The remaining operational prototype effort will test the cell against the remaining system requirements and validate the controls and diagnostics designs via integrated testing and operations. The mechanical prototype is assembled, and preparations are under way for mounting and alignment tests.

Power Conditioning. The power conditioning effort during the past quarter was focused on completing the design of the first article so that parts could be ordered and on using the existing $2 \times 2 \times 5$ capacitor prototype module to refine and validate a detailed circuit model. The model was then modified to reflect the design of the $2 \times 3 \times 4$ first article and predict its performance. Several meetings of the design team were held to resolve the issues regarding the first article design. Among the decisions made were the following: the use of coaxial cable instead of twin-line, the architecture of the first article module ($2 \times 3 \times 4$), the grounding strategy for the bank / amplifier system, and the details of the preionization pulse requirements. A scale model of the first article module was completed and is being used to develop maintenance and safety procedures for the bank, as well as to help the design team evaluate the architecture. The life test of the baseline (ST-300) switch commenced in order to demonstrate adequate life and performance at the elevated currents associated with 24-capacitor operation.

Beam Transport System (BTS). Final checking and documentation for critical path components were highly focused activities in this quarter. The installation schedule drove all resource priorities. The first two procurement packages, for the Laser Bay steel material and spatial filter vacuum vessels, were completed and reviewed, including checked and signed drawings, engineering calculations, and all Title II deliverables. The BTS structural / mechanical analysis team completed the Title II analyses and final analysis reports for the BTS Laser Bay structures, the Bldg. 298 laydown area grading activity is under way, the amplifier cooling system fan units have begun fabrication and are on schedule, and the stainless steel plate is on schedule.

- The spatial filter vacuum vessel designs were completed, and drawings were signed and released into Configuration Management (CM). The fabrication specification was completed and reviewed. Mill production of stainless steel is nearing completion and is on schedule.
- Discussions with Los Alamos National Laboratory (LANL) regarding the proposed Roving Mirror system design, space allocation, alignment, installation sequence, and cleaning issues for the switchyard enclosures were continued. BTS has finalized its decision to perform design and installation of enclosures using internal rather than external resources to allow more schedule flexibility for the Roving Mirror changes proposed by LANL system.
- Ports were added to the Laser Bay interstage beam tubes for clean air purge in the event of in situ maintenance. Seal testing was initiated to evaluate three candidate materials (solid silicone, silicone foam, and expanded Teflon tape) and a number of bolt patterns at both switchyard and Laser Bay pressure differentials.
- The PEPC team recently made a change to use self-contained, local dry pumps to provide backing turbomolecular pumps for the vacuum system. Therefore, a separate backing line to the PEPC is no longer needed from Auxiliary Systems.
- Leak rate measurements for one design of the beam tube seals was completed to validate the design of the gas-handling system.
- The Switchyard 2 structural support structural drawings are about 80% complete, and the structural steel quantity takeoff (spread sheet) is 95% complete. It includes everything but LM5 support subframes because some member sizes are not available.
- Finite-element analysis plots of forces and moments necessary for the completion of the concrete pedestal reinforcement design calculations for the Laser Bay were generated. Pedestal design is nearing completion. Steel-concrete interface force data for the pedestal embedment plates was prepared.
- Tests of o-ring, flat gasket, and formed gasket seal designs for the spatial filter lens prototype were conducted. All three seal designs met the design requirements. These test results provide high confidence in proceeding to final, detail drawings for the spatial filter lens cassettes (see Figure 4). The prototype testing has shown that formed gaskets can be used in place of o-rings at lower cost and similar performance.
- A modified transport mirror attachment design was tested during February. This modification contacted the bore in the back of the mirror at its midplane, which reduced the distortion induced on the front face. Interferometer tests confirmed that a significant reduction was achieved. Improvements to address two problems, plastic deformation of the attachment and creep of the elastomer within the attachment, have been identified.

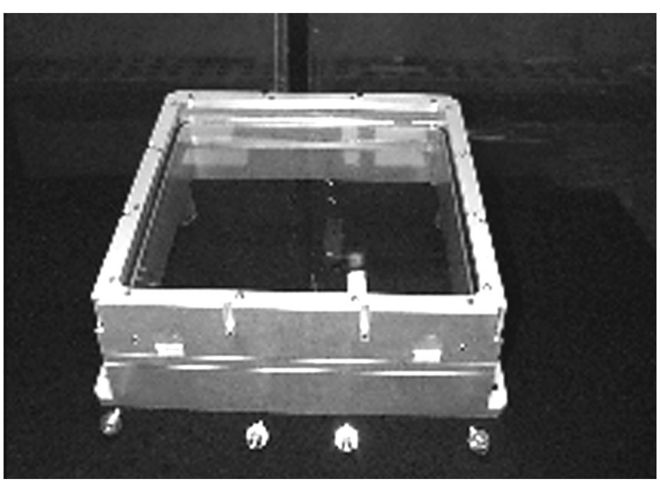

FIGURE 4. A single spatial filter lens assembly is shown above on the left. Four such assemblies are installed into a cassette, which has a strong back for stiffness/handling (shown on right). (50-00-1098-1989pb01 and 50-00-1098-1990pb01)

Integrated Computer Control System (ICCS). Title II 100% Design Reviews were conducted a month early for the Computer System and the Supervisory Software Frameworks.

- The 100% design review for the computer system and network held in February featured 153 drawings, all of which are under configuration control. The network design has evolved since the 65% review to become a hybrid topology of switched Fast Ethernet and Asynchronous Transfer Mode networks. Analysis of expected traffic over the full-shot cycle combined with simulation study shows that substantial performance margin exists in the design. The prototype operator console was delivered and installed in Bldg. 481-1206 for conducting ICCS testbed demonstrations.
- The Title II 100% Review of the Software Frameworks was delivered in February. The review featured a number of presentations on the framework including front-end processor (FEP) preparation, operations databases, system management, status monitoring and reporting, CORBA distribution strategy and measurements, and results from the discrete event simulation for the status monitor performance.
- The report for the 65% Design Review for the integrated timing system was released. In total the reviewers generated 46 comments, of which 7 were level one, 35 were level two, and 4 were level 3. The review committee recommended that an additional prototype of the timing distribution backbone be pursued to demonstrate precision timing requirements and ensure continuing vendor involvement leading to NIF deployment.
- The Control Logix integrated safety system beta unit was received from Allen-Bradley and activated for testing. This unit represents the next generation of higher-performance programmable logic controllers and will form the basis for the NIF Industrial Control Systems.
- The Preliminary Timing Analysis of NIF Beamline Alignment was finalized and used to demonstrate Alignment Control's ability to meet Software Subsystem Design Requirements (SSDR) alignment time specifications in support of the 65% review. This analysis defines the step-by-step alignment procedures from the Preamplifier Module (PAM) through the Target Chamber and includes how shared resources (such as the Output Sensor and Target Chamber) impact system performance.

Optomechanical Systems Management. Title II design progress was very good. Spatial filter lens cassette prototype testing was completed. Mirror attachment design testing continued with moderate success. Transport mirror sizes were determined. Most of main laser cavity optics final drawings have been released. The FOA Mid-Title II (65%) design review was held. The final optics configuration was updated to incorporate ECR180. Major pieces of FOA prototype hardware were received. The CAVE (Crystal Assembly Verification Equipment) became ready to begin manual measurements.

Optical Design. Title II optical design progress during the second quarter included the following:

- The final, planned update to the main laser design optical configuration drawing was released. The optical design of the main laser cavity is complete.
- The optical design of the OPG system was presented by the responsible optical engineer at the Mid-Title II (65%) review in February. Important results were reported for the optical stability analysis, the wavefront specifications for optical components, the optical layout (under CM), and the optical design performance.
- Detailed optical design studies of the telescopes in the preamplifier beam transport section (PABTS) of the OPG were completed and showed that a lengthening of the relay telescope was necessary to reduce fluence on lenses within the telescope. As part of the system design, the telescope in the input sensor package was also redesigned to better balance the energy loading.
- Good progress was made on releasing final main laser optics drawings into CM. The following drawings have been released: amplifier blank, spatial filter lens, cavity mirrors and polarizer, switch window, and diagnostic beamsplitter. The remaining cavity optics drawings (switch crystal and amplifier finishing) are being updated by the optics manufacturing organizations.
- The Title II mirror sizes for the transport mirrors were determined. The alignment scheme (i.e., which mirrors would be used to control pointing to the target and centering at the final optics) had to be changed to obtain mirror sizes acceptable to the various interfacing groups, generally decreasing in size. As a result, the final drawings (nine) for the mirror blanks were released.
- Two out of six FOA optics drawings are under CM (target chamber vacuum window and focus lens). The final sizes of the diffractive optics plates and debris shields were established and the Title II drawings should be released in April.
- The defect-induced damage analysis calculations for the NIF vacuum barriers investigated the beam modulation at spatial filter lenses (vacuum barriers) arising from defects in optical components. The results showed that the presence of

defects modulates the beam slightly more than fabrication phase errors, but that this modulation is below damage thresholds. The results confirm that the polarizer and LM3 are the most sensitive locations for defects.

Optical Components. Several potential qualified suppliers have expressed strong interest in supplying the BK-7 mirror and polarizer substrate materials for the NIF. In contrast to the other materials, BK-7 is a commodity glass requiring no special facilitization or development efforts. The statement of work was written for these substrates in conjunction with the release of the Title II mirror and polarizer substrate drawings.

Significant progress was made in NIF small optics in the second quarter. A list of prototypes and a delivery schedule were developed, along with a vendor survey from which a qualified bid list will be developed for production optics. The Vendor Qualification Plan was also completed and released on schedule.

The small-sample cleanliness verification system was completed, as was a comprehensive technical review of the large-optics processing plan. This review included a status of the following areas: all optics processing support facilities for the NIF, QA for optics processing, staffing and training, database documentation, facility and process cleanliness control, and mechanical handling equipment and fixtures. The requirements document for the Metrology Data Management System, which will be used to assist inspection and quality assurance (QA) of the optics at the vendors and LLNL, was updated based on input from the optics component lead engineers and the vendors.

Laser Control. Considerable progress has been made in completing and reviewing parts of the laser control design. In addition, various prototype components were ordered, received, and assembled, with more on the way.

- The Transport Spatial Filter area now has a fully integrated design that encompasses the mechanical, optical, and electronic systems for the preamplifier module, injection beams, alignment and diagnostic beams, input sensors, output sensors, and beam enclosures.
- Solid modeling of the Input Sensor package is essentially complete, and some detail drawings are also finished.
- Signal level requirements for beam control light sources were analyzed in more detail using a complete NIF transmission model for all optical paths from the light source locations to the corresponding detectors. The model compared well with the transmission elements of current beam propagation codes, and the two methods are believed to be equivalent.
- Substantially all of the mechanical parts for the Output Sensor prototype have been received, and assembly is being planned. Similarly, all purchased parts for the sensor test stand are in hand while fabrication parts are on order.
- The optical design of the Laser Optic Damage Inspection (LODI) System was modified to accommodate 3ω light. When the Schlieren focus stop is removed, LODI can be used to record near-field images of light that have made a round trip to the final optic and back. This will likely be part of an on-line system for measuring the net 3ω reflectivity profile of the 1ω transport mirrors.

Target Experimental Systems. The Target Experimental System has continued Title II design according to schedule, for the most part.

- All 18 target chamber plates have been formed and shipped to Precision Components Corp. (PCC) for edge machining. The first sphere plate edge machining was done at PCC, with the long sides of the plate receiving the weld groove configuration. The land of the weld joint will be at a 5064 mm (199.38 in.) radius on all pieces (see Figure 5). This will facilitate alignment and use of semiautomated welding equipment.
- Stainless steel louvers appear to work for both the x-ray panels and beam dumps in the target chamber first wall. Tests showed that either B4C or stainless steel louvers pass the requirement, which is the debris shield contamination rate limit. Stainless steel louvers are substantially cheaper than B4C louvers, and since the base material does not matter, there is no strong reason to go to the additional expense of B4C louvers.

  Work is proceeding to test a prototype stainless steel louvered beam dump on Nova. The fixture is designed and is being reviewed with Nova personnel. The stainless steel louver without a vertical member has been tested on 2-beam, and a

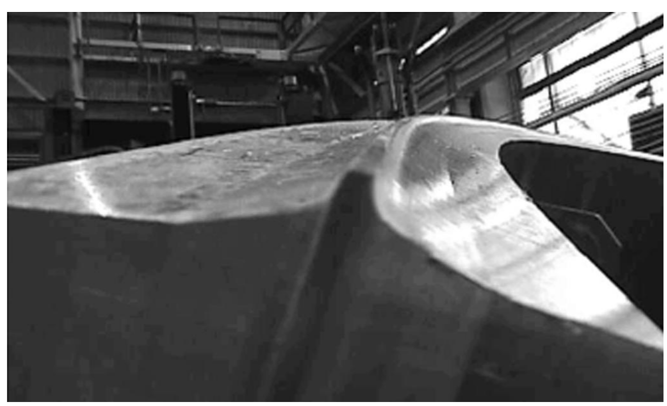

FIGURE 5. Shown is the radiused weld prep that has been machined on one of the target chamber sections. (40-00-1098-2033pb01)

larger panel with 45° louvers with vertical members will be tested on Nova.

- The 65% Title II Design Reviews for the target chamber vacuum system and the target positioner were held this quarter. Creation of detailed mechanical drawings for the Target Bay vacuum components assemblies and detailed design of the positioner are proceeding.
- A Diagnostics Working Group Meeting was held at Jackson Hole, Wyoming, to present the status of the NIF design and discuss the diagnostics to be placed on the NIF and other laser facilities. Data Acquisition, Calibration facilities, X-Ray Diagnostics, and Neutron Diagnostics were also discussed. Participants included representatives from LLNL, LANL, Sandia National Laboratories (SNL), Laboratory for Laser Energetics (LLE), and Atomic Weapons Research Establishment (AWE), who are also developing a Web page to share diagnostic design information. It will soon be password accessible by diagnostic users.
- The design of the diagnostic instrument manipulator (DIM) is proceeding. AWE has designed and is starting the fabrication of a test setup to verify the design of the rails that mount the insertion tube and the z-axis motor design. Detailed drawings of this test setup have been received. AWE is reviewing the DIM development schedule and LANL has volunteered the Trident laser facility for evaluating the prototype DIM.
- The Q31T mirror support frame, the largest and most complex, is located in a position within the Target Area Building that experiences the most severe environmental conditions. For this reason, it has been extensively analyzed to validate the proposed structural design, and detail drawings are being prepared so it can be a model for the remaining frames.

Final Optics Assembly. Title II second quarter progress for the FOA is summarized below.

- The Mid-Title II (65%) FOA design review was presented in February. All mechanical subsystems were reviewed: integrated optics module (IOM), final optics cell (FOC), debris shield cassette, actuation system, alignment fiducial arm, 3ω calorimeter chamber, vacuum isolation valve, thermal control system, and vacuum/venting system. The optical configuration was described, and a scientific update on frequency conversion, with special attention paid to the performance error budget, was also given. Analysis results presented included structural, seismic, thermal, and computational fluid dynamics.
- The optical configuration was revised to implement the requirements imposed by ECR180 (additional diffractive optic cassette). Extensive ghost analysis and optical chief ray tracing provided detailed input to establish the revised configuration.
- Work has focused on incorporating ghost mitigation measures (e.g., absorbing glass) into the IOM. The ghost analysis has indicated that two sides and both ends of the of the IOM require mitigation. It is highly desirable to use glass that is textured appropriately to diffuse or scatter the incident light, thereby reducing the fluence on subsequent surfaces. Work has also been proceeding on ghost control in the FOC. Two sides of the cell are "illuminated" by stray light at sufficient levels to require protection. The baseline scheme involves covering the sides of the cell and the retaining flanges with absorbing glass. Key test data is needed for the damage limits of various materials (aluminum surfaces, ceramics, and absorbing glass) to complete the design.
- Major pieces of FOA prototype hardware were received: the calorimeter chamber, three integrated optics modules, large test stand, and debris shield cassette hardware. The test stand was installed in Bldg. 432, and the pumping system

FIGURE 6. The full-scale FOA test stand (large steel structure in center of photo) was installed in the Bldg. 432 high-bay in March. A CAD representation of the FOA has been superimposed to illustrate the soon-to-be-installed hardware. The actual vacuum isolation valve is shown on a support stand at the bottom of the photo. (40-00-1098-2032pb01)

was located at the base of the stand, as shown in Figure 6. It will permit testing of the prototype hardware in an orientation consistent with installation on the target chamber. The vacuum isolation valve will be installed after the valve body is caustic-etched, and the revised bell crank mechanism is fabricated. The calorimeter chamber is ready for installation thereafter.
- All hardware for the CAVE has been delivered and assembled in Bldg. 432 (see Figure 7). Specifically, the following items were installed: optical table, temperature-controlled clean room, high-power laser, and large reference mirror. The laser operational safety procedure and interlocks were approved so that operations can begin.

Operations Special Equipment. Title II design is progressing well. Hardware prototyping is providing excellent cleanliness data and design validation. During the second quarter, the group completed the Transport and Handling (T&H) 35% Review, the OAB Mid-Title II (65%) Review, and an Informal OAB Corridor Review.

- Line-replaceable unit (LRU) refurbishment meetings with various LRU owners continued in order to develop requirements for refurbishment. Requirements for LRU and equipment movement in the OAB corridor were documented. The drawing package of the corridor is now complete.
- The detailed designs of the bottom-loading, top-loading, side-loading, switchyard, and Target Area delivery systems are progressing well. The 35% Review was completed this quarter.
- The interface and Phase II requirements review was held this quarter with RedZone Robotics, Inc. / AGV Products, Inc. to clarify the Laser Bay transporter deliverables and the requirements of the design. Permission was given to the vendor to start procuring long-lead items for the fabrication of the first vehicle.
- The assembly and testing of the T&H prototype hardware is progressing well. The "clean" testing of the cover removal mechanism for the bottom-loading canister has begun and will be completed next quarter. The assembly of the components for the insertion mechanism is complete, and dirty testing of the mechanism has begun. The hardware for the scissors mechanism and vacuum cover has been fabricated, and assembly will start in April.
- The OAB hardware designs and the simulation model were presented in February at the Mid-Title II (65%) design review. The review was highly interactive, key areas of interest were discussed with the interface partners, and all comments have now been addressed.
- The software requirements specifications were completed for the FEPs for bottom-loading, top-loading, side-loading, and switchyard delivery systems. The control points (sensors, actuators) for all T&H prototype delivery systems were specified. A draft interface specification was completed identifying data interfaces between the Laser Bay transport system computer systems and the T&H FEPs and Supervisory System. A "proof of concept" graphical user interface of an OAB integrated desktop was presented at the OAB 65% review and received very positive feedback.

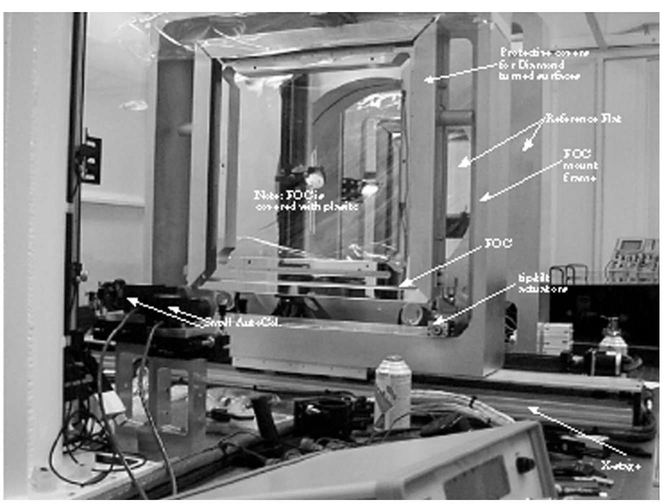

FIGURE 7. The CAVE FOC mount, the reference flat, horizontal slide, and autocollimators for tracking tip / tilt as the mount is translated. (40-00-1098-2031pb01)

Start-Up Activities

Integrated Project Schedule (IPS) Assessment. The month-end March status of the IPS showed no impact to Level 0–3 milestones. Current schedule issues are (1) the coordination challenge of interfacing Conventional Facilities multiple subcontractor activities with Special Equipment activities, (2) restructuring the Optics schedule module in the IPS from process-based (development / facilitization / pilot / production) to component-based (windows / lenses / mirrors / polarizers / etc.) activities, and (3) adding equipment installation details to the IPS.

Start-Up Planning. A draft Start-Up Plan for the first bundle has been completed on schedule. The purpose of this plan is to outline the sequence of integrated system Operational Test Procedures, which constitute start-up of the first bundle of eight beam-lines. These integrated tests will be conducted once all first bundle special equipment in Laser Bay 2 has been installed and Acceptance Test Procedures have been completed. After start-up has been successfully completed, the first bundle will be ready for ICF / NIF Program experimental operations.

Advanced Operations Planning. A draft *NIF Operations Procedures Plan* document has been completed. The NIF Start-Up and Operations Planning Group is responsible for providing the management and technical oversight necessary to ensure a smooth project transition from the construction and equipment development phase of the NIF to integrated beamline operation in a fully functional facility.

Optics Technology

Facilitization efforts are proceeding well. The initial evaluation of the Schott laser glass melting campaign at the end of the first quarter was very promising. The glass was formed at full size without any major problems with inclusions or fracturing. Minor problems with the melter and batch feeding system will be addressed when the melter is rebuilt for the pilot production campaign in the first quarter 1999. Though not all of the specifications were met during this campaign, the assessment both at Schott and LLNL is positive. Hoya started and completed its final subscale campaign at the production facility in Fremont, California. The glass met nearly all the NIF specifications, but OH content needs to be reduced slightly. Fine annealing of both the Schott and Hoya glass will be complete in the third quarter, so the glass can be evaluated for homogeneity.

Facilitization of the remaining four rapid crystal growth tanks was accelerated during the second quarter due to the early decision to select rapid growth as the baseline process for NIF crystals. Several crystals were fabricated from development boules for frequency conversion testing on Beamlet; the optical quality and damage threshold meet NIF specifications.

Finishing facilitization at Zygo is on schedule and going extremely well. The NIF facility was formally dedicated in February 1998. The start of the Tinsley building construction was delayed from November 1997 until April 1998, primarily due to the extended rains. Aside from the building, most of the equipment design and construction at Tinsley is on schedule.

Coatings facilitization contracts were negotiated and signed with Spectra Physics and LLE in the second quarter. Veeco Process Metrology, formerly Wyko, delivered interferometry unit Nos. 2 and 3 to LLNL and Hoya, respectively. Facilitization efforts in other metrology areas, including photometry and surface inspection, also went well.

Upcoming Major Activities

During the third quarter of FY98, Conventional Facilities will complete the CSP-3 Target Bay and Mat Foundations work and begin the CSP-4 erection of the Laser Building steel. In the OAB, the concrete foundations will be completed, and the steel work will begin. In Special Equipment, the 65% and 100% design reviews will continue at a faster pace, and procurements will be initiated for some of the Beam Transport items such as the Spatial Filter Vacuum vessels. In Optics, the contracts for mirror and polarizer substrates should be placed, and the vendor facilitization activities will continue.

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