Preliminary Findings and Recommendations of the OLUG Workshop:
A work in Progress (18 June 2009)

I. Introduction

Extensive discussions occurred during the workshop, in both formal and informal settings, regarding (1) ways in which the Omega Facility could be more effective in utilizing existing resources and (2) new capabilities or technologies that would be highly desirable from the OMEGA Users' (i.e., OLUG) point of view. Before turning to particulars, it is important to stress that there was a resounding response by the workshop attendees that the Omega Facility was extremely well run and that the team that operates OMEGA is both highly dedicated and very skilled. To them and the facility, we want to first and foremost express our deep gratitude.

Two workshop reports were written. The first was by the OLUG Executive Committee and was a best attempt to summarize the view of all workshop attendees (some 100 professional scientists and engineers, academics, students, and postdocs from 4 countries). Its findings were grouped into the following five areas: *60-beam OMEGA (***II***); OMEGA EP (***III***); General Users Issues (***IV***); Informational Flow (***V***); and Broader Issues (***VI***)*. The second report was written by the Student/Postdoctoral Panel and its findings and recommendations strongly reflect the point-of-view of students, postdocs, and, in general, new users at OMEGA. Concise, coherent, and insightful, the student/postdoc report is deserving of our careful attention.

When reading these two reports, however, one is struck by the many common issues between them, especially those relating to information flow and to the process of preparing for and executing science campaigns in the OMEGA environment. This commonality is, in part, due to the challenging complexity, especially from the point of view of new users, of the facility and its operations, even though there are myriad tools at OMEGA to help navigate through this process. Indeed, as will be obvious even in the different sections of the Executive Committee report itself, these same themes, aside from the technologically specific recommendations of those sections, were oft repeated. Since the management response was written to address the issues that were raised *strictly* on the last day of the workshop (1 May 2009), and because the sections of the Executive Report, as was the management response, were written several days after the workshop, there is a slight mismatch between issues of the formal Executive Report [contained herein in Sections II – VI] and the Management Response. In part because of this, but more importantly due to the complexity of some of the issues involved and the need to iterate back and forth from recommendations to what is actually achievable, from the management point of view, this Report must necessarily be considered a work in progress.

II. 60-Beam OMEGA

In the course of our working-group discussions, the users developed a list of desired improvements enabling better use of the Omega 60-beam Facility. The list that follows is in order of priority, reflecting both the degree of resonance across the users and the degree of importance to specific subgroups of users.

1. **Delay and conflict information**
   A web page providing the top 15 or so typical delays generated by decisions about how to construct an experimental day. Examples would include the delays associated with repointing beams or with moving a framing camera. This is of value to help users better develop their initial plans for shot days.

2. **More options for driving the legs**
   The minimum functionality sought here is less than the ultimate one. The ultimate functionality would be the ability to drive any leg from any driver. Indeed, we recognize that this is a tall order. The minimum functionality is the ability to use the SSD driver on one leg while using another driver on the other two legs. (A way to achieve this might include enabling the backlighter to drive any two legs.) Having the capability of operating SSD and main drivers simultaneously is potentially quite important to x-ray Thomson-scattering experiments, an emerging area where much greater activity can be anticipated.

3. **More static x-ray PHC's**
   These diagnostics are rarely, if ever, critically important but are of value in assessing whether an experiment went as intended. Their number has dropped over recent years and it would be helpful to see a few cameras re-activated somehow.

4. **More SG8 or similar phase plates**
   This would be specifically useful when users share shot days. Whether SG8's are in fact the right choice or how this integrates with phase plates for OMEGA EP was not addressed. Most users would agree that having some phase plates for OMEGA EP is far more important than having additional ones for OMEGA 60.

5. **Spherical Crystal Imaging**
   This would be a very useful diagnostic if implemented and engineered to the point of being routinely available. The users understand that this would be an expensive prospect and would not rank it above other ways to spend the necessary funds. The users would strongly encourage support for any effort by a major laboratory to implement this diagnostic.

III. OMEGA EP

1. **Beam Smoothing**
   The use of Distributed Phase Plates (DPP's) significantly improves the spatial uniformity of irradiation in the focus of high-power laser beams. Their use has been shown to reduce the growth of parametric instabilities, which have a number of deleterious effects, such as the generation of hot electrons (this causes preheat of the irradiated targets) and reduced coupling of the laser energy to the plasma.

OLUG recommends the installation of DPP's at 1 mm on the long-pulse beamlines. This provision would benefit a number of users of the facility.

In addition, temporal smoothing can be achieved with the implementation of Smoothing by Spectral Dispersion (SSD). OLUG is aware that a preamplifier module (PAM) is being installed at the Omega EP Facility to study two-dimensional SSD for direct-drive ICF at the National Ignition Facility (NIF).

OLUG urges facility management to make the necessary modifications to the NIF PAM so that it can be used as an alternate front end for OMEGA EP and allow 2-D SSD studies to be implemented for the academic user community.

2. **Pulse Shaping**
   The NIF will be using long-pulse durations for some studies. Staging experiments from OMEGA EP to the NIF may need similar pulse shapes in the future.

   OLUG recommends that options for implementing pulse shapes similar to NIF (100 ps to 30 ns) are explored by management so that an assessment of priorities can be made at the next OLUG meeting.

3. **Intensity Contrast-Ratio Enhancement**
   The coupling of energy from the intense laser pulse to the fast electron beam may be significantly affected by magnetic fields formed near the ablation front by the plasma generated by the prepulse. These fields have the effect of reducing the number of fast electrons entering the target. It may be necessary to improve the intensity contrast ratio to get better coupling.

   OLUG recommends that options for enhancing the intensity contrast ratio are explored by management so that an assessment of priorities can be made at the next OLUG meeting.

4. **Implementation of Low-Energy Probe Beams**
   Optical probes provide a range of powerful diagnostic tools that can be used to extract information from underdense laser-produced plasmas. Density gradients, for example, can be obtained from both shadowgraphy and Schlieren imaging, while density information can be extracted by unfolding interferograms, and magnetic fields can be obtained with the simultaneous use of polarimetry. The working group is aware of the funded project to implement a 10-ps fourth-harmonic probe line for OMEGA EP by the end of this financial year.

OLUG urges management to make the completion and realization of this project a very high priority. These diagnostics will be of great assistance to a large number of users of the facility.

5. **Addition of Streaked Optical Pyrometry (SOP) with the Active Shock Breakout (ASBO) Diagnostic**
   The Active Shock Breakout (ASBO) diagnostic has proved to be a valuable tool to study high-pressure equation-of-state of materials, as well as shock timing for inertial confinement fusion. The instrument has been used extensively by investigators based at a number of universities and national laboratories since the upgraded instrument was commissioned in 2006. A laser probe beam is used to illuminate the rear surface of the target. When the shock wave reaches the back surface of the witness plate, it rapidly heats the surface, resulting in a dramatic reduction in reflectivity of the probe beam. This makes it possible to measure shock breakout times with high temporal and spatial resolution.

   The provision of two "velocity interferometer for any reflector" (VISAR) channels is a unique feature of the upgraded instrument. These channels have different velocity sensitivities that enable any 2-D ambiguity that arises at velocity discontinuities to be resolved. The working group agreed that the addition of passive Streaked Optical Pyrometry (SOP) channels would be a valuable addition. They would allow the lower radiation temperatures and shock pressures to be measured.

   OLUG recommends the simultaneous provision of SOP with the ASBO diagnostic suite.

6. **Spherical Crystal Imaging**
   Monochromatic x-ray imaging of high-photon energy K_α radiation has proved to be a valuable tool in diagnosing energy transport in intense laser–plasma interactions. This has provided information in cone wire plasmas: for example, the energy coupling and the resistive electric field required to draw the return current. Many experiments will benefit from provision of Ti, Cu, and higher-Z K_α imaging spectrometers.

   OLUG recommends the provision of a spherical crystal imaging diagnostic in OMEGA EP.

7. **Record of Electromagnetic Pulse (EMP) and Radiological Noise**
   High-intensity laser environments are harsh. Active diagnostics suffer considerable damage because of EMP, x-ray bremsstrahlung radiation, and (p,n) induced activation of diagnostics placed close to the targets.

   OLUG recommends that a record is made available to facility users of instruments and detectors that have suffered from EMP and radiological

noise damage so that mitigation strategies can be undertaken when planning experiments.

8. Penalty and Conflict Information

It would be very useful when preparing experiments to have an appreciation of the time delays that are likely to occur as a result of changes to diagnostics, target alignment, and laser specifications during experimental campaigns.

OLUG recommends that a record be made available to facility users of known delays so that facility users are more aware of the costs of decisions.

IV. General User Issues

A number of issues were discussed that are common to users of both OMEGA and OMEGA EP. These issues are based on operational details relevant to preparing and executing experiments, as well as the flow of information and communication between facility personnel and users, as well as among users themselves. The following points summarize these issues and *recommendations*:

1. A number of users have indicated that it would be important to have a larger volume of information and knowledge about facility operational details and the way in which they can impact the setup and execution of experiments. For example, the connection between changes in laser pulse energy, shape, and smoothing options during a shot day, and their impact in shot delays, including a possible loss of shots. In general, the issue is: What is the optimal way to plan for these changes during a shot day (e.g. what is best to do first, second, etc.)? The idea is that what actually happens during the day (or half day) of shots is likely to be a compromise determined by practical facility operational details and considerations of science goals. Along the same lines, how can changes and modification of diagnostic configurations during the shot day, relative to what was discussed in the initial plan, impact shot execution, and what conflicts or incompatibilities may arise?

In this connection, the idea was proposed of having the option of starting the discussion process of the detailed experimental proposal for the shots with relevant personnel in the facility several months ahead of time.

At the moment, this is currently done as the result of the submission of the experimental proposal two months ahead of time. The OMEGA and OMEGA EP users would like to have the option of starting this discussion process earlier or have alternative avenues available to them to address these issues.

2. Another point of common concern that was brought up at the workshop is that of calibrating and characterizing diagnostics available on OMEGA and OMEGA EP. In this connection, flat fielding of streak and framing cameras is a typical example that is relevant to many users but certainly not the only one; however, it is a good case for illustration. The performance of streak and framing cameras has a broad impact on

experiments since they are used in a variety of experimental campaigns, in different ways, to record valuable time-resolved data. Currently, users have to plan for characterizating and flat fielding these cameras as part of their own shot campaigns. Yet, the information they produce in this regard is potentially useful to many users. The idea was discussed at the workshop that it would be more efficient and effective if this information could be made available to users on a standard basis, and if it could be generated in such a way that it did not tax the shots dedicated to a given science campaign; i.e., if it did not require dedicated shots allocated to a user that could have otherwise been used to address a science point. Two possible ways to address this issue were discussed. On one hand, characterization and flat fielding of streak and framing cameras could be done as a ride-along task; this would require planning and organization so that opportunities are not missed and sufficient and reliable information is recorded to achieve this goal. On the other hand, the facility could dedicate shots to perform this task or could include it as part of their regular facility maintenance.

Regardless of the way in which it is done, it was clear from the discussions at the workshop that there is strong consensus among users in that characterization and calibration of diagnostics available on OMEGA and OMEGA EP is an important point affecting many users and that it is a critical issue that must be addressed.

3. Evaluating and assessing the Omega Facility performance and the experimental campaign was another important topic of discussion. This is an important issue since it provides an opportunity for users to convey feedback and comments to the Omega Facility. Current procedures on OMEGA include an Effectiveness Assessment form that must be returned by the PI to the Shot Director after each shot, and an Experimental Critique sheet that is submitted during the week after the week of the shots. The sense among users was that, while there is value in the feedback provided in the Effectiveness Assessment form, this is done under pressure and too hurried. The quality of the feedback and comments provided in the Experimental Critique sheet is better the week after the shots. However, a thorough overall assessment of the experimental campaign including, in particular, the quality and quantity of the data recorded and how well were the science goals achieved, is something that often requires considerably more time.

OLUG recommends having the option to provide feedback on the experimental campaign, including facility performance, target fabrication, and level of accomplishment of science goals a few months after the shots. This feedback is likely to be the most accurate and realistic. The idea was also suggested to provide a place on the OMEGA website accessible by users (via login and password) indicating the current status of OMEGA and OMEGA EP diagnostics.

4. Better and more-complete information about the instruments and diagnostics available on OMEGA and OMEGA EP are needed.

This could be accomplished by establishing links in suitable web pages on the OMEGA website, including (but not limited to) Shot Request forms (SRF's), to

internal reports and journal papers that document the details of instruments and diagnostics.

5. The role that Chuck Sorce plays in LLNL experimental campaigns as a link between scientists (PI's) and facility engineers and technicians has been noted and praised by many users not involved in LLNL campaigns.

It was suggested at the workshop that it would be useful to have a similar resource person to perform that task for all experimental campaigns.

6. OLUG recommends the continued use of Be in OMEGA and OMEGA EP shots.

7. OLUG recommends additional office space for (outside) users be allocated when they are visiting and preparing for their OMEGA shots.

8. OLUG recommends that space be provided on the OMEGA website to post information of common interest to many users as well as to establish web pages for areas of interest for groups of users; e.g., Thomson scattering, x-ray spectroscopy, particle measurements.

V. Information Flow

This topic involves better communications with Omega Facility users. Generally, the communication between LLE and users is conducted very well; however, the amount of information required for a successful campaign on OMEGA is very large. The suggestions below represent the distilled recommendations of the Users' Group to improve communications, *which is especially important for those who have no internal connection with LLE or are new users.*

Diagnostics

1. Just as the laser-pulse-shape "Help" page describes choices for laser pulses, a "Help" page for diagnostics would be of great benefit. This might be accomplished with an upgrade to the ***Diagnostic Status*** link on the OMEGA operations page. To the list of "Diagnostic Name" and "Lead scientist," etc., *the upgrade* would add a brief description (couple of sentences), available SRF choices, and links to published papers employing the diagnostic. For x-ray imagers, the page could list the date of the last flat fielding.

2. If possible, a search-engine capability for diagnostics is attractive because it could enable would-be users to find out *who has recently used or is planning to use* specific diagnostics. The search could cover all SRF's within a +2/–1-month window with the idea of returning the names of PI's (who composed the SRF's) so that potential users of that diagnostic could contact them regarding how well it functioned and exchange details of actual/intended use. This should not violate accessibility/restriction of SRF's to users who may not be authorized to view an SRF in totality but is intended only to better communicate reasonable knowledge from one user to another. A corollary to this is an LLE-sponsored blog or "wiki" for areas of user interest; e.g., x-ray Thomson scattering or x-ray framing cameras.

3. A new LLE notification procedure concerning *diagnostic status* would benefit users. Just like at national laboratories, where a person is notified when credit for various training courses necessary for employment is about to expire, PI's could be notified if a primary diagnostic for their upcoming campaign becomes "unavailable." The implementation for this might involve automated email to all PI's for shots for the next ~2 months (a time period to be determined) when a diagnostic goes "off line." This may result in an increase of email to PI's who are not interested, but could also result in a reduction of surprises to PI's who are counting on using a particular diagnostic for future shots for which SRF's have not yet been created.

4 Not all diagnostics are LLE diagnostics. Occasionally, it is desirable to test or flat field a user's diagnostic prior to the user's shot day. One means through which this might be accomplished is to provide an "empty-TIM" web page. Similar to the ***Diagnostic Status*** page, this page would list all empty TIM's for shots occurring during the next quarter. It could list the shot PI, the campaign, the target characteristics, and the laser energy on target. The intent of this exercise is to enable ***ride-along*** testing of a user's diagnostic. Perhaps more often than not, such a ride-along would not be reasonable. Occasionally, however, such multiplexing of experiments may increase the overall productivity of the Omega/Omega EP Facility. As examples, the "neutron days" often conducted by Vladimir Glebov attract a host of users with various TIM diagnostics that benefit from testing. Another example is the pointing shots conducted for LLE cryo shots. If a user's imaging diagnostic or spectrometer can be fielded as a ride-along, or an x-ray flat fielding can be accomplished without costing a shot, this would be an increase in productivity.

OMEGA EP Information

A high level of enthusiasm for OMEGA EP exists. Although it is recognized that OMEGA EP is a work in progress, the users' community is eager for status reports on OMEGA EP. The Executive Committee recommends that, as soon as is practicable, members of the users' group receive updates on

- OMEGA EP pulse-shaping capabilities, including
  - minimum pulse length
  - energy limits in relation to pulse width
  - OMEGA EP contrast
  - blast-shield status
  - energy/power/focusability limits with blast shields

Miscellaneous

Similar updates are desirable for other OMEGA systems:

- Phase-plate availability and numbers for both OMEGA 60 and OMEGA EP
- DT-fill capability, especially with regard to changes of procedure that may affect LLE's ability to fill and field targets

VI. Broader Issues

The Executive Committee expressed concern about the absence of explicit support for diagnostic development in universities. This has an exacerbating effect upon hands-on training in an era of increasingly formal facility operations. This issue is especially important to students and postdocs.

There is also a concern about the availability of small facilities as staging grounds for hands-on training, diagnostics, and experiment development. Again, students and postdocs are significantly impacted by this circumstance. Although OLUG recognizes that the concern expressed in these two paragraphs are really outside the purview of the Omega Facility, it is an issue that does impact the researchers, especially younger ones who come to LLE to perform experiments.

With regard to related research at other facilities, OLUG recommends that we proceed with the HIPER/US workshop to promote joint and complementary research on HEDP physics. In a similar vein, efforts should be made to coordinate and promote complementary physics research between Omega and other important HED laser facilities such as the NIF, LULI, RAL, Trident, and Texas PW. Through such coordinated activities and research, there are substantial opportunities to significantly advance the science of high-energy-density physics.