AFRL-HE-BR-TR-2004-0026

United States Air Force Research Laboratory

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October 2004

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This report has been reviewed and is approved for publication.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
October 2004

2. REPORT TYPE
Final

3. DATES COVERED *(From - To)*
15 July 1997 -- 1 May 2003

4. TITLE AND SUBTITLE
Optical Research & Field Services

5a. CONTRACT NUMBER
F41624-02-D-7003

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
62202F

6. AUTHOR(S)
Dean Knisley, Dennis Maier, Joseph Zuclich, Peter Smith, Dan Huantes

5d. PROJECT NUMBER
7757

5e. TASK NUMBER
B2

5f. WORK UNIT NUMBER
98

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Northrop Grumman Information
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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Research Laboratory
Human Effectiveness Directorate, Directed Energy Bioeffects Division
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Brooks-City Base, TX 78235

10. SPONSOR/MONITOR'S ACRONYM(S)
AFRL/HE

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
AFRL-HE-BR-TR-2004-0026

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release, distribution unlimited.

13. SUPPLEMENTARY NOTES
This report documents the details of accomplishments under this Task Order contract. Each Task Order was closed with a TR also.

14. ABSTRACT

Research under Contract Number F41624-97-D-9000 began in the summer of 1997 and continued through May 2003. This close-up report contains a summary of the scientific accomplishments and activities that the Northrop Grumman team performed in support of the Optical Radiation Branch as part of this contract. Under the Scientific Accomplishments, we have described the major research projects and the Task Orders that supported each of those major research areas.
A bibliography of AFRL Technical Reports, Papers, Articles, and Abstracts authored and co-authored by Northrop Grumman employees ia published as part of this report.

15. SUBJECT TERMS
Optical Research, LEP, HEL, short pulse lasers, laser safety, susceptibility, range safety, vision science

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Capt Larry Schad
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(include area code)*
Unclassified	Unclassified	Unclassified	Unclassified	95	(210) 487-3271

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

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1. INTRODUCTION

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2. SCIENTIFIC ACCOMPLISHMENTS

2.1. Personnel Susceptibility to Optical Sources

Scope: Provide research and research support in the area of personnel susceptibility. General tasks included experiments to understand the human visual system and its susceptibility to sources of optical radiation, model development for the human visual system and its susceptibility, development of hardware to exploit susceptibilities, assessing susceptibility to existing sources, and the development of hardware which simulates the susceptibility effects for mission rehearsal purposes.

Significant Activities

Work began on Saber 203 characterization in late 1997. A "Safety Guidelines" report authored by the Saber 203 Measurement Team was submitted and added to the Saber 203 Measurements project plan. TASC delivered the "White Paper on Saber 203 Eye Safety Analysis" to AFRL/HEDO on 26 September 1997. The report contained a summary of extended source criteria applied to the Saber 203 illuminator device. The compatibility of the Saber 203 with the MILES (Multiple Integrated Laser Engagement System) gear used in USAF combat training exercises was tested. The test results indicated that the gear would not be activated by the Saber203 system. Also tested were two infrared illuminator/pointers (ACP and GCP). Neither laser system activated the gear.

The optical component setup for automated measurements was accomplished during February 1998. Additional work on the setup included the mounting procedure for the Saber IUs for consistent alignments and data acquisition/analysis automation. Measurement of the 36 IOT&E units and eight demonstration units was completed. Data analysis was conducted and a report summarizing the results was delivered in August 1998. A technical report summarizing all of the Saber 203 measurements conducted by AFRL/HEDO was prepared.

Retinal damage thresholds were based on exposures in a total of 12 eyes in seven subjects and data were collected until the fiducial limits for both the ED50 and ED10 thresholds narrowed to approximately +/- 10%, indicating a very high statistical confidence in the threshold data. The experiment was completed except for the pathologic evaluation of four exposed eyes (two subjects). TASC members of the Saber Evaluation Team proposed the "technology transfer" of hazard analysis and laser characterization techniques and software to commercial applications. A revised cost to complete analysis for the Saber 203 measurement project was prepared in July 1998. The revised analysis included time for HALT system measurements as well as FDA/ANSI laser classification work. A preliminary schedule and budget was prepared for follow-on HALT, LE System and Dissuader systems. Laser characterization of five HALT Laser technology demonstration units was performed in November 1998.

The final report documenting measurement results of the first set of 10 CTE Laser Dissuader devices was received and assigned Consultative Letter (CL) number AFRL-HE-BR-CL-1999-0011. Hazard evaluation calculations were performed for insertion into the draft consultative letter *Laser Hazard Assessment of the LE Systems Green Laser-Baton Illuminator (GLBI)*. A draft report for the ocular laser hazard analysis of the 532nm green laser baton for the red-green study was completed. This report contained a proposal to evaluate effectiveness of the red (650nm) versus green (532nm) lasers to reduce visual function during a military visual search task. Green Laser Baton Illuminator (GLBI) irradiance measurements were made at distances of 10m, 25m, and 40m to compare measured exposure with modeled exposure. The measured data was within 20 percent of the predicted exposure.

TASC and Karta personnel prepared an overview of the Non-Lethal Technology (NLT) Laser Illuminator Program that was briefed to the LSSWG Conference on 12 October 1999. The presentation included a demonstration of the DISSUADER and HALT devices. The *SABER 203 Measurements Summary Technical Report* was approved and published.

2.2. Personnel Susceptibility to Optical Sources: HEL Safety

Scope: Develop new policies, procedures and tools for high energy laser safety.

Significant Activities

In March 1998, TASC installed the TRA program and all associated configuration and data files on the SGI Indigo 2 at the Litton-TASC office. This installation allowed the software engineers to become familiar with the operation of the program. Analysis of the software focused on program use – creating and editing scenario files, including target flight profile, weapon platform flight profile, weapon characteristics, and terrain data format. The terrain files received with the program represented only the position of the coastline, but not the terrain elevation. The TRA program itself supports inclusion of terrain elevation in the geometric reflected beam calculations, but the utility that was provided for generating the terrain files from DTED data did not extract the elevation data. TASC wrote a utility program that extracted coastline and terrain elevation data from the DTED data and formated it in the native TRA terrain format. In addition, a converter was developed to convert Digital Elevation Model (DEM) data to TRA format. Because of limitations in the TRA software, the converters had to be modified to reduce the number of output points to a level that the TRA could process. Requirements for the Laser Range Safety Tool were refined in preparation of the new tool being developed by Logicon RDA.

Team members visited with the technical staff at the High Energy Laser System Test Facility (HELSTF) at White Sands Missile Range in June 1998. Discussions centered on lessons learned during the early test firings of the Mid Infra-Red Advanced Chemical Laser (MIRACL), as well as current safety considerations relevant to the upcoming ABL tests. Discussions also focused on the safety issues associated with the Tactical High Energy Laser (THEL), and resulted in an invitation to participate in the monthly THEL safety meetings. TASC personnel attended the Airborne Laser Preliminary Design Review (PDR) for Safety Issues. TASC visited RDA Logicon to review their progress on the Laser Range Safety Tool, with a focus on the assumptions, analysis, and algorithms used in the software development. As a result, TASC was asked to provide a preliminary eye safety analysis for the use of the ABL target board under design by CSA Sensors.

TASC reviewed available material on the prediction of atmospheric scintillation during the ABL firing, as well as the personnel hazard associated with the laser's reflectance from the target's rocket plume. TASC reviewed and provided comments on the LRST System Requirements Specification submitted by RDA June 1. This document was discussed with RDA during the Airborne Laser Environmental Safety and Health Preliminary Design Review. In July, TASC supported another trip to Albuquerque to review the status of the development effort. Model development used the Satellite Assessment Center's Modeling Tool (SMT), which provides models in the format used in the LRST. TASC visited RDA/Logicon in Albuquerque to participate in a Technical Interchange Meeting to review the status of the LRST program. The meeting demonstrated that RDA was lagging in the development of this program and still needed to determine and define the approach they would use to model the physical aspects of the problem to calculate laser exposure. TASC also lead the effort to develop sample test cases that would be used to compare the output from the LRST program with independently calculated results. Eight test cases were developed that focused on simplified scenarios over the White Sands Missile Range. Initially, calculations were made for one of these cases and provided to RDA to assist in software development and initial verification. The remaining cases were calculated independently for use in V&V after program development. TASC also installed the Satellite Assessment Center Modeling Tool (SMT) on the SGI computer and began developing simple 3D target models that RDA could use to run sample test cases.

TASC continued to develop technology for Probabilistic Risk Assessment (PRA). Available data for assessing the hazards associated with 1315nm laser light were reviewed. Recommendations were made regarding type of studies needed (e.g., corneal, skin, whole eye), appropriate pulse durations needed, as well as energy/power requirements). A subcontract was let to SEA, Inc. of Albuquerque, NM, to help host a conference on this subject. TASC worked to develop a project plan for a probabilistic risk assessment to quantify HEL hazard statistics under conditions where a reflected beam traverses a medium-sized population area (Alamogordo). The results of this study were presented at the PRA conference.

Preliminary ordering information was gathered on optical benches, optics, and related apparatus to begin equipping a laboratory for the startup of bioeffects studies on the HEL wavelengths of interest. Lists of specific equipment were finalized, assistance was provided in development of justification documentation, and the experimental protocol was formally submitted to the Brooks AFB Animal Use Committee.

TASC was heavily involved in working the details of the Battlefield Lasers '98 Conference held in the United Kingdom the first week of November. This included arranging and rearranging agenda, extensive communications with host POCs in the UK, and wrestling with a host of other administrative details. In addition, TASC provided several papers and presentations at the conference. TASC attended and participated in the Battlefield Lasers '98 conference and made follow-on visits to Pilkington Optronics and the DERA Malvern Research Site in the UK.

Working with the staff of HEDO, TASC supported follow-on meetings on the review of the physics associated with the Laser Range Safety Tool (LRST). A number of issues were discussed concerning the approach that RDA plans to use in the LRST. A set of questions to present to RDA was developed.

TASC continued to use the Satellite Assessment Center Modeling Tool (SMT) on the SGI computer to refine the simple 3D target models that will be used by HEDO/TASC and by RDA to compute the results for a set of sample test cases previously developed. These models include both dull black painted and polished aluminum versions of a round plate, a sphere, a cylinder and a cone. TASC investigated how the BRDF data are coupled to the physical models.

With respect to Probability Risk Assessment, TASC reported at the December 1998 IPT meeting that there did not appear to be existing models readily available to use in the study of population susceptibility. TASC was instructed to go ahead and begin the study and to obtain the population data from the US Census Bureau. For this study TASC established a spatial population model of a small (approx 20,000) community and then performed Monte Carlo simulations of high energy laser "encounters" affecting the community. The objective was to determine the best probability distribution function to describe the number of people likely to be impacted by such an encounter. In-lab validations of the LRST program focused on scaled studies with a Nd:YAG 1064nm laser in a laboratory setting, and on development of field tests of different size to examine scaling effects.

A partial delivery of the LRST program was provided to HEDO by RDA/Logicon. This version of the program provided a User Interface under MatLab to the LRST physics code compiled as a DOS executable. The source code for the physical algorithms was not provided by RDA. This program was setup on the "Linus" server at HEDO, where a version of the MatLab program had already been installed. This version of the program was not analyzed extensively since the source code of interest was not made available.

TASC acquired a debris model and set of results prepared as part of the ABL Environmental Impact Statement (EIS) Appendix G. TASC used these results to estimate ocular hazards from reflection off debris following missile breakup. Debris illumination was assumed to be at 50,000 ft altitude; various debris sizes were examined. Preliminary results indicate that there will be no ocular hazard to ground observers from reflection of the high energy laser beam of the ABL off any debris. TASC drafted a letter to begin collaborating with the Army Center for Health Promotion and Preventive Medicine (CHPPM) to measure reflections during the THEL tests at WSMR.

TASC continued the work of analyzing and characterizing the LRST source code. The high-level structure of the program was analyzed, recognizing that many of the details were still undefined. TASC setup the LRST computer in the new modeling and simulation lab and installed the Matlab version of LRST on it. The versions of the operational LRST provided by RDA did not run on NT, but the source code for this version was installed on this computer. TASC also ordered both C++ compilers needed for these two versions of the LRST – Borland C++ Builder for the operational LRST, and Microsoft Visual C++ for the Matlab version.

In support of the Advanced Concept Testbed (ACT) at North Oscura Peak (NOP), TASC developed test plans for the June, July and November NOP tests at White Sands Missile Range (WSMR). On 22-24 June, TASC personnel participated in the initial target board tests at WSMR and measured reflection data from the scoring beam ground test. The TASC team was hosted at the site and provided with a first-hand view of the ACT on NOP. The TASC team also visited the scoring beam receiver site at the top of Salinas Peak.

TASC, SEA and AFRL/HEDO jointly hosted the First Conference on the Use of Probabilistic Risk Assessment (PRA) for High Energy Laser (HEL) Safety. TASC directed final preparation activities for the conference (with 47 attendees) that was held from October 20-22, 1999 in San Antonio, TX. TASC also provided administrative and technical support throughout the conference. The conference successfully accomplished AFRL/HEDO's goal of bringing together appropriate experts to discuss DOD needs, current technology, and new tools to be developed to support future high-energy laser risk probabilistic risk assessments. The conference was truly international, with participants from UK, Austria, Israel, DOD and industry providing excellent presentations and lively debate on how to develop a PRA program tailored to the requirements of HEL systems.

In May, 2000, TASC prepared a summary report on the completed short pulse 1315nm studies. The report detailed the effects found during retinal, corneal and lenticular exposures.

AFRL/HEDO personnel and TASC team members traveled to Albuquerque, NM and White Sands Missile Range (WSMR) to participate in the Non-Cooperative Dynamic Compensation Experiment (NoDyCE). TASC visited the North Oscura Peak (NOP) telescope site and discussed plans for future field tests. Though the collection system was set-up and successfully tested against various light sources at WSMR, all four aircraft tests were cancelled due to weather.

The LRST software validation effort focused on improving and formalizing the procedures to test new releases of the program from Logicon. The June 7 release was the first opportunity to use the test procedure script. Using this procedure we identified 14 problems, which we documented in the Bugtracker database and, using the database program, provided a report to Logicon of these problems. Anticipating that HEDO and TASC would soon be taking over development of the LRST program, TASC began to develop some design documentation for the program. TASC ordered a software tool called Class Explorer Pro that works with the Borland C++ Builder environment and provides excellent design information directly from the source code.

TASC continued working on the image overlay capability for LRST. NIMA's Vector Product Format (VMAP) was identified as the best solution for adding data such as roads, rivers, range and political boundaries to the display.

Data collection commenced on corneal/lens damage thresholds from 10-sec, 1318nm laser exposures using the rabbit as the animal model. Test exposures were also directed to the iris of the undilated eye to estimate the iris damage threshold relative to that for the cornea and directly irradiated lens as well as to search for secondary lens effects due to thermal diffusion from the overlying iris exposure sites. The directly irradiated lens appeared to have the lowest damage threshold for the exposure conditions, although all anterior tissue thresholds (cornea, lens direct, iris and lens indirect) fell within a factor of two or so.

On 14 September, 2000, TASC hosted an ABL White Sands Missile Range (WSMR) Test Hazards Analysis meeting at Brooks AFB to review a laser safety hazard analysis process to be used on an interim basis until LRST is releasable for range hazards assessments. ABL program plans for missile drop tests (MARTI) and WSMR flight tests against a target aircraft orbiting north of the ABL aircraft were reviewed. AFRL/HEDO agreed with the concept used to determine direct beam hazard potential.

TASC continued to analyze data collected during the Low Power Chemical Laser (LPCL) test. Scatter signal results for each target were tabulated. In addition, TASC drafted an outline and completed the preliminary section of a Technical Memo. TASC analyzed the NoDyCE beacon peak-to-peak data to characterize the scintillation of the laser beam. TASC used this data to calculate the atmospheric transmission based on a given beam irradiance at the test site.

TASC prepared an Installation CD of the LRST program, thus meeting the original objectives of the plan briefed to the ABL SPO on August 22 that included a professional installation program and a nominal help file. TASC continued work to improve the help file, add test scenarios for White Sands tests, and add a complex missile target to the program capabilities. TASC also continued the important work of documenting the software design in some detail in order to gain a better understanding of the software architecture and function.

Background research on the use of Probabilistic Risk Assessment (PRA) elsewhere by the USAF revealed a report by the Committee on Space Launch Range Safety entitled *"Streamlining space launch range safety."* This significant finding describes the quantitative risk management approach used to support space launches and includes numbers for the common risk criteria agreed by the Range Commanders Council. It can also be used as a precedent to support the application of PRA to laser safety. The report indicates that the risk modeling approach uses population databases that are required for PRA modeling.

Analysis of the Low Power Chemical Laser (LPCL) data in January 2002 provided TASC new target scatter (Bi-directional Reflectance Distribution Function) data from the Optical Measurement Facility. This data was analyzed and compared to the Laser Range Safety Tool predictions and to measurements conducted during the LPCL test.

For the software development of the LRST, TASC completed the Beta release, including development of the draft user's manual. Installation CDs were produced and training sessions held at both Vandenberg AFB and White Sands Missile Range (WSMR). The course consisted of an intensive three-hour introduction to LRST followed by an extended hands-on period. During both portions of the training, the participants showed great interest in the program and its capabilities. TASC finished both training sessions with the impression that the students grasped the concepts in operating LRST-Beta, and that TASC would receive useful feedback in the form of bug-tracking and GUI recommendations.

The Matlab version of LRST was used to produce a time-slice intensity laser profile on the ground for a typical HEL engagement, and work started on subjecting this profile to a subset of the PRA probability density functions (for atmospheric scintillation, population density, and ocular damage). Effort focused on atmospheric propagation, and a typical scintillation model was implemented. Addition of other PDFs demonstrated the amelioration of hazard zones by probabilistic risk assessment techniques.

Also in support of the ABL program, TASC developed a game plan for obtaining certification for testing the ABL Active Ranger System (ARS). Planned test profiles for this system (as flown from Boeing facilities in Wichita, KS) require a unique certification analysis and coordination with Regional FAA representatives. TASC contacted DoD range personnel and FAA military liaisons in the Kansas City area to obtain additional information concerning the certification process.

The database editor now provides functionality for editing sources (which represent the ABL aircraft), targets, sites, and three types of observers (point, planar, group) as well as numerous relatively minor simulation entities. Many of the editing screens now display user-selected units of measure. User input is accepted in the selected display units and converted into LRST internal units. The edit dialogs provide range checking on all input values with friendly, informative notification to the user when an input value is out of bounds. LRST now provides for four types of planar observers: horizontal planar observers, vertical planar observers, range-boundary observers, and airspace observers. Provision has been made for a fifth type, a volumetric observer, where a three-dimensional volume of space may be populated with observer points.

TASC made good progress on the Trajectory Editor. All six of the major transformations required to relocate a trajectory from one location to another are now in place. Integration of the relocatable trajectories with LRST can begin as soon as the relocation process has been thoroughly tested. Provisions have been incorporated for the relocatable trajectories in the LRST database and database editor. Progress was also made in the map display module of LRST. The Laser Range Management System (LRMS) rendering engine has been ported to the Borland development environment and integrated with the body of the LRST simulation code.

In the HEL lab, TASC successfully constructed a specialized target mount for cylindrical target validation testing. The mount spins the target and thus helps reduce variations in scatter signal measurements caused by laser speckle (interference). The mount rotates the target thereby causing speckle spots to move across the detector aperture. The detector/meter has built-in electronic hardware (analog & digital filters) that can then be used to effectively time average the dynamic speckle pattern received at the detector aperture. TASC investigated several options for adjusting the laser beam incident on the cylindrical target. LRST predictions will be much more sensitive to incident beam parameters than for our flat plate tests.

TASC reviewed the previous months HEL lab data to determine the optimum set-up for the remaining LRST validation experiments. TASC determined that a converging linearly polarized beam was best for comparisons of hand calculations with lab measurements, and a circularly polarized collimated beam was best for comparisons of LRST predictions with lab measurements. TASC recommended additional flat plate scatter measurements at 30-degree laser incident angle and against a green painted target.

On May 31, TASC planned and co-chaired a HEL Integrated Product Team meeting. TASC presented status briefing on LRST development, LRST validation, Probabilistic Risk Assessment, ABL SPO consultation support and HEL program marketing efforts. TASC advised the customer the task order 18 ceiling limit would likely be met if not raised in the next six months.

TASC (now Northrop Grumman) assisted in preparing presentations on the HEL Safety Program and the LRST V&V effort for the Directed Energy Professional Society (DEPS) symposium. As part of the HEL safety long-term strategic planning effort, Northrop Grumman continued to assist AFRL/HEDO by organizing and hosting a third "off-site meeting" at the Koger Center. Senior members of the HEL IPT Team attended the meeting and completed discussions related to task identification, task prioritization, and near-term resource allocation (12-18 months).

Northrop Grumman hosted meetings with two separate vendors who submitted bids for a short pulse width (nanosecond), 1315nm wavelength laser system. This type of laser is not available off-the-shelf and as such will be a prototype purchase. Preliminary cost estimates were in the region of $300K.

In preparation for LRST training, Northrop Grumman prepared a new LRST release (version 1.1) and a high quality LRST User's manual and tutorial guide. Individual LRST CDs and manuals were prepared for each student. From 22 to 26 October, Northrop Grumman provided on-site LRST v1.1 training to Range Safety Officers at White Sands Missile Range (WSMR), NM.

A meeting was held in March 2002 to determine future FDA Exemption requirements for the ABL program. Specifically, the Laser Design Checklist derived from MIL STND 1425A and ANSI Z136.6 was reviewed. The ABL SPO recently requested that this information be expedited so they can be ready to begin negotiating production costs with Boeing on short notice. It was determined that 35 of the 72 requirements were not applicable to laser systems on the ABL aircraft. Many of the remaining requirements are covered or can be easily met. Sixteen items will likely require a conference call between the ABL SPO, Boeing and AFRL/HEDO to determine if current ABL designs meet the requirements.

Work continued on LRST version 1.04. A new interactive terrain marker was developed to facilitate the interpretation of results. The new markers allow the user to interactively point at the terrain with the mouse cursor and position a graphical cursor at that location on the terrain. The marker consists of a 3D cursor (red/green/blue coordinate jack with transparent cut planes), the latitude, longitude, altitude text for the point, and an optional text string. The coordinate jack indicates true North (the red axis), East (the green axis), and down (the blue axis). The latitude and longitude are displayed to four decimal places (5 meter resolution at the equator). The altitude is displayed to one decimal place and the units conform to the user-selected units of linear measure. Each of these features may be turned on/off under user control, allowing the marker to be used for a variety of purposes, such as placing text on the terrain. The user-interface for the Trajectory Editor underwent major rework. The confluence of features added to the program made the original graphical interface extremely difficult to use. The new user-interface design substantially improves the user's ability to control the graphical depiction of the trajectory.

Following provision of ABL funds, work commenced on database restructuring. The original database (v1.04 and earlier) was diagrammed, documented and analyzed. The software development team proposed a goal of having a visible improvement by the August 2002 time frame. In addition, in an attempt to verify radial symmetry by removing any "curved world" tilt from the hypothetical scenario, the orientation of the scenario was changed to a vertical one by moving the laser to the ground and placing the target 1km above ground level. The V&V team continued detailed testing of the Bi-directional Reflectance Distribution Function (BRDF) extraction tool. The highlights of the testing included comparisons of p-p and s-s polarized laser scatter measurements (from OCEL and OMF) versus the extraction tool simulated laser scatter curves.

Northrop Grumman received the new laser to support cylindrical target HEL lab testing. To prepare for the next set of cylindrical target scatter measurements, the laser output characteristics, including power; wavelength, and divergence were measured. The optical detection system was reconfigured, incorporating a Helium-Neon laser to align the optical axis of each component. In addition, a beam expansion system to collimate the beam and provide the desired spot size on target was designed and set up. Finally, a rail system was set up to ensure repeatability in locating the measurement system relative to the target.

Northrop Grumman continued HEL laboratory target scatter data collection efforts to validate LRST. The HEL lab test matrix against cylindrical shaped targets was completed. Cylindrical target measurements included elevation angle variations and overfilling the target with the incident laser beam. In general, LRST predictions were again lower than the laboratory measurements. Additional lab tests to check measurement accuracy were conducted, and no errors in set up were found. At present, uncertainties in the Extraction Tool appear to be the most likely source of differences between experimental results and LRST predictions.

Modifications to three LRST applications in support of LRST 2.0 development were completed on schedule. Northrop Grumman modified LRSTEdit, LRSTSim and the Trajectory Editor applications to ensure that these applications were compliant with version 2.0 of the LRST Database. All of these applications must be compliant with this version in order for LRST to run properly, and, in many cases, to run at all. LRSTEdit now both reads and writes data to the Binary Large Object (BLOB) fields of the LRST Database. LRSTSim now successfully reads BLOB data from the LRST database whenever a scenario is run in LRST. It is imperative that LRSTSim "knows" where to find this data whenever a scenario is run, otherwise the application will crash and scenarios cannot be run. The Trajectory Editor is now able to communicate with LRSTEdit so that LRSTEdit "knows" what updates need to be made to the database, based on user input to the Trajectory Editor.

After a prolonged effort to repair the LRST BRDF Extraction Tool, a major breakthrough was achieved thanks to assistance from the Northrop Grumman team in Albuquerque, NM. The success was primarily due to using a better nonlinear optimization technique (Levenberg Marquardt) and simultaneously solving for each of the desired Maxwell Beard model BRDF parameters. Several variations of the fundamental Maxwell Beard algorithm were checked. In the end, a variation using improvements to the model proposed by the Optical Measurement Facility at Wright Patterson AFB provided the best results.

A preliminary hazard analysis for the ATL target acquisition, ranger, and illuminator lasers was completed in support of the ATL program. Northrop Grumman used LHAZ to determine the NOHD and LEP OD requirements for these laser systems. In addition, TASC has supported numerous requests for LHMEL field test information from the TERA team that is assessing ATL system hazards.

Northrop Grumman revised sections of the LRST User's Guide to reflect program improvements incorporated into version 2.01 (and version 1.04). The changes to the user interface of the Database Editor were substantial enough that this section of the manual was almost completely re-written. In addition, major revisions were made to the Trajectory Editor version of the User's Guide and guidance for the Import/Export tool was added. As part of the continuing LRST development effort, Northrop Grumman made several improvements to the v2.01 release. First, the production version of LRST now contains a menu-selectable switch that will set the target material BRDF to that of a pure Lambertian surface. Second, a Golden Sphere visualizer was added. These first two improvements will help with the continuing VV&A effort. Finally, the AGL/MSL modes for the Screen/Site markers were updated. The Site Markers may now be either snapped to the terrain altitude or placed at any desired altitude.

High-level and low-level LRST design documentation was generated for the VV&A effort. Both types of design documentation were written for the Trajectory Editor, the Import Export Tool, Registry Editor, and the LRST Database Editor. The design documentation was presented for review to the LRST VV review committee. Design documentation for the Trajectory Editor and the Import Export Tool was approved by the committee and forwarded to the designated LRST Validation Agent to be officially accepted and coordinated with the LRST Accreditation Agent. Minor changes to the Registry Editor documentation were made. After the committee approved these changes, the documentation was forwarded for sign off. This marked the completion of the required design documentation for the three above-mentioned LRST components.

The LRST Software Requirements Specification (SRS) was edited to reflect the current state of the software development process in accordance with direction from the accreditation agent. Requirements that do not and will not appear in LRST were removed. Requirements that are satisfied by the existing version of the program (LRST v2.03) were marked as "Done". Requirements that have been projected to appear in future versions of the program were labeled as such.

Verification tests were conducted on LRST's Lambertian cylindrical shaders. Northrop Grumman worked on comparing the LRST Cylindrical Hypothetical scenarios to a MathCad-based Laser Evaluation Model (LASEM) code for various incident angles. Multiple LRST scenarios were created and run. The results were compared with the output of the LASEM code. All of the LRST predictions agreed very well with the LASEM code predictions, indicating that the cylindrical shaders are functioning correctly.

The latest modifications made to the standalone (non-unified physics) version of the BRDF Tool were integrated into the unified physics version, which was verified to produce the same answers as the standalone (non-unified) version of the program. Future enhancements to the tool will be developed with the unified physics version and all development on the standalone version of the program ceased. A specification for enhancements to the BRDF Tool was begun. The existing BRDF Tool provides an excellent platform for testing and developing the BRDF extraction process, but is insufficient for the task of producing a complete materials database. The enhancement specification is meant to identify new features needed in the BRDF Tool to support the production of an AFRL/HEDO materials database from new laboratory measurements.

2.3. Personnel Susceptibility to Optical Sources: Susceptibility and Modeling

Significant Activities

Flashblindness Study.

The objective of this study was to establish or estimate the visibility of targets of various brightnesses during and after interpulse periods of low pulse repetition frequency (4-5hz), short pulsewidth (30ns) visible lasers (532nm) of varying output powers (MPE to ED50).

PGM Windscreen Scattering Project

The major effort was conducting the F-16 laser glare ground test at Edwards AFB, CA. The major goals of obtaining lab personnel and pilot data were accomplished, but the test team was not able to complete the fully anticipated data collection. Only two of the planned three pilots were available for testing. In addition, because of limited time and the desire to minimize the cumulative laser exposure, the full complement of data was not collected on the other two pilots. Only one or two trials were collected for each condition. As much data as possible was collected in the time available and the data was a valuable asset for more accurately predicting visual effects from laser exposure. A modeling analysis of the laser exposures required to produce a visual sensitivity deficit that would abort a PGM weapons delivery was performed. The loss of visibility of HUD symbology for 10 seconds over a 1.25deg diameter field of view was established as the eye defeat criterion. The analysis was performed for a variety of day and night viewing conditions. The radiant exposures required to meet the eye defeat criterion were related to the MPE and ED50 exposures.

LTAS 2.0

TASC helped gather user requirements for the development of LTAS 2.0. Work was performed enhancing and optimizing algorithms and drawing techniques for the LTAS GUI and map display. This work included enhancing and optimizing the Laser Threat Scenario (LTS) drag and drop capability of the LTAS map display. The LTAS graphical user interface (GUI) was modified to reflect changes to core routines. The Eye Kill Threat ring was removed and changes to the atmosphere specification and customization section were also implemented. The input panel function that changes the user profile from standard mode to advanced mode was modified to enhance this feature. Within LTAS, all optic elements were scalar in that there was no 2-D profile of the spatial distribution of the laser energy. Such a distribution was required in order to properly ascertain the light distribution on the back of the retina. This requirement is one that enables accurate mathematical representations of a number of intervening optical systems and materials such as canopies, NVGs, LEP, and other media that affect the distribution of the propagating laser energy. LTAMPS can produce line-of-sight (LOS) openings to the ground as a function of: 1) slant range, 2) minimum altitude (which can be close to AGL at a specified latitude and longitude), and 3) maximum altitude AGL. This produces LOS rings on the ground or on a map similar to the ones LTAS produces, but considers a range of altitudes and works under the assumption that a clear LOS at altitude Z1 for a fixed position will always produce a clear LOS to the same point on the ground at an AGL greater than Z1.

Key government and TASC technical personnel who were involved in LTAS development over the past several years met to get feedback on the history of the project and ideas for how to proceed further with the project. A consensus of TASC personnel agreed that TASC should support the upgrade of existing databases and models and the merging of LTAS version 2.0 with the Navy's LTAMPS software. The improved LTAMPS would constitute a platform into which the LTAS model and database improvements could be incorporated, resulting in a "state of the art" laser threat assessment capability supporting research and operational needs. TASC participated in two major meetings to work out a specific plan for the upgrade of LTAS and the integration of its components with LTAMPS in FY00 and FY01. The plan, complete with specific budgetary numbers and staffing requirements, was submitted to AFRL/HEDO on 29 November 1999.

Laser Threat Modeling Component (LTMC)

TASC completed a preliminary integration of the LTMC damage component with the Navy LTAMPS program and provided a demonstration of its product at the 21 July 2000 meeting of the LTMC IPT. This demonstration showed how LTMC portrays minimal visible lesion (MVL) and nominal ocular hazard (NIHD) distances as "spheres" on the 3D. Following approval by the Air Force, TASC began to revise the current stand-alone hazard model (LHAZ) to be able to incorporate the new LTMC hazard algorithms. As of the end of April, the LTMC "damage" component was effectively complete and LHAZ version 4.0 was readied for "beta" testing following installation of a graphing routine. TASC conducted limited testing of LHAZ 4.0 in different software languages. A meeting was held on 30 April 2001 to review the status of the LTMC "vision" component implementation. A "programmer's guide" was provided to follow in re-constituting the former LTAS glare and flashblindness models into LTMC. The LELAWS software has been completely integrated into LTMC as a stand-alone class ("CLELAWS"). In collaboration with the "Flashbang" subcontract with Veridian, the atmospheric scattering model developed as a part of the old Directed Radiator (DRAD) project was resurrected. The model was integrated into LTMC. Some work was also done to migrate the existing LHAZ Broadband (BB) application that was originally written using LabView into C++.

The MPE Qualifiers capability was added to LHAZ. A project plan was developed through the end of the year with milestones set for LHAZ 4.4/LTMC 2.2 and LHAZ 4.6/LTMC 2.4. Numerous GUI changes were needed to implement the Multi-Wavelength capability scheduled for LHAZ 4.4. Taking this into consideration with the plans for LHAZ 4.6, it was decided that this functionality would not be included in LHAZ 4.4 but in LHAZ 4.6.

Holographic Study

AFRL/HEDO received project funding from AFRL/HE-1 for a feasibility study regarding the deceptive use of projected holograms. This project was similar to a SBIR Phase 1 in that the study reviewed the current state-of-the-art in projected holograms, evaluated the maturity and suitability of use of said technology, and made recommendations as to future work if the technology could meet the requirements for military holographic projection applications. Alex Ferdman of Zebra Imaging, Inc., of Austin, Texas exhibited their reflectance holograms at the DEL on 14 October. There was much interest in having Zebra develop a custom image. It was decided to use Zebra's holograms to evaluate the utility of holograms for use in IO/IW applications. HEDO purchased two holograms from Zebra, one of a human head and another of a model of an F-22 aircraft. Approval was obtained to purchase the YF-22 texture model from the Viewpoint Model Bank, and the F-22 physical model was received from Lockheed-Martin.

Dr. Deanna McMillan of Zebra Imaging presented a prototype version of the animated hologram to NGIT and AFRL/HEDO personnel on 16 August 2001. The animated hologram protocol was approved by the Brooks IRB on 24 August 2001 and sent on to AFRL/HE and the USAF Surgeon General for final approval. The animated hologram was returned to Brooks AFB during the semester break at UTSA, but no data collection on the animated hologram study occurred during this period. Further discussions were held concerning the lighting system to be used in the multiple-message hologram and TASC (now Northrop Grumman) requested a rough estimate from Zebra Imaging of the cost of producing the multiple-message hologram.

SH-60L Static and Flight Test

AFRL/HEDO supported the Naval Health Center Detachment Four's "SH-60" flight test at Fallon NAS, Nevada.

Laser Transient Effects

A meeting was held 30 November 1999 to discuss new technical leadership for the Transient Multiple-Pulse Effects study. The plan was for a 10Hz train of 1-msec

532nm laser pulses to be presented for up to 10 sec, with visibility assessed by subjects' adjustment of the luminance of a diffuse tungsten test stimulus. TASC held a multiple-pulse study demonstration on 8 July 2000 in the Navy psychophysics lab. The complete laboratory setup was displayed and the experimental protocol that the subject was to receive was previewed. Operation of the safety features was demonstrated, and deliberate attempts to "trip" the dedicated safety circuit with out-of-bounds exposures functioned as designed and successfully interrupted the beam. All systems operated as intended. Preliminary observations are that the inability to perform the visual task will occur at laser exposure levels far beneath those specified in the protocol, lessening the potential risk to the subject. Final development of the multiple-pulse laboratory was completed. A safety inspection was conducted on 14 December 2000 and the laboratory set-up was deemed acceptable from the safety standpoint. The multiple-pulse protocol was approved by the Brooks Institutional Review Board (IRB) on 31 August 2001 and sent on for approval by AFRL/HE and the USAF Surgeon General. The experimental setup in the Navy psychophysical laboratory was re-established and the luminance of the test spot re-measured with the new PhotoResearch telephotometer. The luminance was essentially as estimated in the draft technical report for the first study.

Solution Technologies for Aviation-Related Tactical Laser Exposure (STARTLE)
Support continued for the LCADD ("helicopter dazzler") project, and TASC purchased a revolving laser pointer (known as a "laser leveler") for demonstrations of the feasibility of the LCADD concept.

Nonlethal Technology
A draft of a human-use protocol for the Phase II lens-fluorescence study to compare the effects of on-axis and off-axis violet vs. red laser beams was completed. Preliminary tests were done with isolated, fixed monkey lenses. Final approval for the Phase II protocol comparing violet vs. red laser glare effects on human visual search was granted by the USAF Surgeon General on 8 August 2001. Final data collection from the study on the effects of violet vs. red laser exposures on visual search was completed. It was agreed that analyses-of-variance (ANOVAs) would be performed on 1) the reaction-time (RT) data, with timeouts not included, 2) the RT data, with timeouts included as 1.5-s RTs, and 3) the percentage of correct responses.

Measurements to support the laser hazard assessment for the HAVE-STAN laser system were completed. With customer consent, the preliminary laser hazard analysis was delayed due to competing priorities with the ORS IPT. Work on migration of the visual search task for the four-laser study was completed and some timing measurement checks undertaken. In addition, a routine to vary the contrast of the stimuli was written.

3-D Perception Management
Bids were received from two computer graphics firms for the 3D animated image acquisition. After reviewing the bids, Northrop Grumman chose Geometrix to record the 3D image. Northrop Grumman completed negotiations with Zebra Imaging to record a multiple-message animated hologram at a fixed price of $32k.

Although this was $11.5k above the original estimate, Northrop Grumman considered the offered hologram to be of such superior quality that no competitor could match it. In order to make up the budgetary overage, Northrop Grumman reduced the scope of the pilot study from about 20 to 10 participants.

The video message using compressed frames was completed and sent to HECA for review. We arranged with Galaxy Scientific to provide 55 participants at their test facility. The Multiple-Message Hologram protocol was submitted for internal HEDO review. The software to control the lighting apparatus was completed up to the stage where it could be tested with the illumination apparatus.

Laser Modeling
A conceptual plan for the next generation of LHAZ (to be designated LHAZ 5.0) was developed and reviewed. Some prototyping was done to verify that certain Win32 API interfaces worked as documented. A number of defects in LHAZ 4.4 (beta) that were identified were also corrected. Copies of LHAZ 4.4(beta) Professional were sent to ACC/DRX. The design of the LHAZ 5.0 Framework Analysis and Properties interfaces and plug-in architecture was completed. Work on the laser modeling effort focused on the completion of changes to the LAAST application requested by ACC/DRX, who received a two CD software distribution package at the end of April. The first CD was a multimedia laser safety and information training package, and the second CD was the HEDO developed LAAST tool. This release went to a limited audience as an "alpha" distribution. In addition, effort was expended on developing an LTMC doxygen documentation set to be used by developers, external to HEDO, who want to leverage the functionality that is in the LTMC library. This documentation set includes documentation of functionality and examples of how to use the library with common development tools.

2.4. Personnel Susceptibility to Optical Sources: Vision Science

Significant Activities
Strategic planning activities for the vision science efforts were conducted under Task Order #23. Northrop Grumman facilitated a preliminary meeting to initiate these activities. On 6 Dec 2002 Northrup Grumman traveled with AFRL/HEDO to Johnson Space Center, NASA, Houston, TX to attend the Mission Control Center Systems Architecture Team Technology Demonstration and discuss the potential for collaborative research with NASA personnel. Of particular interest were several topics on Virtual Reality and 3D simulations that had some connection to the AFRL/HEDO Perception Management research area. Discussions with NASA included the possibility of developing life-size holographic images of physiologically accurate 3D human models to assist designing space/flight suits. In addition, Tietronix Inc. demonstrated an optical source blocker that had potential for blocking laser radiation from the field of view in optical systems.
Northrop Grumman planned and hosted the first off-site Strategic Planning meeting for the Vision Science program that was held at the Koger Center on 22 Jan 2003. Presentations on the main aspects of the Vision Science elements of the AFRL/HEDO research program, together with general guidance on Strategic Planning, were prepared and delivered.

The initial project under Task Order #23 continued efforts to secure basic research (6.1) funding from the Air Force Office of Scientific Research to support psychophysical investigation of visual intensity-duration relationships for laser exposures. Northrop Grumman provided assistance to AFRL/HEDO by providing a final version of the "pulse-probe" research proposal, which was submitted by AFRL/HEDO to AFOSR. A small amount of funding ($90K) was received by AFRL/HEDO to start this study.

Northrop Grumman expended some effort in discussions with Mobium Enterprises Inc., to determine the type and extent of contribution that they might make to the Vision Science element of the OR&FS program as a subcontractor to Northrop Grumman. Mobium has extensive experience in the vision science aspects of laser eye protection and cockpit compatibility issues gained primarily through work it has performed through AFRL/MLPJ.

2.5. Safety Standards for Optical Systems: Ultra-Short Pulse Research

Scope: Acquire the research and research support necessary to understand the bioeffects of ultrashort laser pulses on the eye and their impact on personal laser protective equipment.

Significant Activities

Software for the Artificial Retina and LABView Programs was written to automate the data recording process. The Ti:Sapphire laser and Regen were repaired and brought back into service. The manuscript on self-focusing was completely rewritten and submitted to Applied Optics for publication. Also, a manuscript was written for the proceedings for the BiosEurope'97 held in San Remo, Italy on September 6 1997, and a presentation was made at that meeting. A draft manuscript was written to be submitted to IOVS on the near-infrared minimum visible lesion data and spot size measurements completed in the previous year.

The annual report for the USAFOSR was completed. A copy of all written and published manuscripts was included. In addition the ANSI standard, proposed revisions were developed and tested to insure that they included all data previously published.

The spot size measurements were completed using the contact lens and all fluence versus retinal spot size for data previously taken was recalculated. A draft manuscript for the spot size data was begun as a standalone paper.

Spectra-Physics engineers spent a week reconfiguring the USP-II system for operation in the 800nm spectrum. They also provided training for optimizing the system.. New mirrors and beam splitters were ordered and the system for MVL measurements at 800nm was made ready for 100fs pulsewidths.
Threshold measurements for 800 nanometer, 130 femtosecond pulses were completed in live primate eyes. These measurements included macular and paramacular exposures on four eyes to obtain ED50 for both sites and to compare sensitivities for the two areas.

An optical signal representing the optical spectrum versus phase shift was observed on the scope and recorded digitally for a 130 fs and 800 nm pulse.

Upgrades to the USP-II laser system were designed to reduce the pulsewidth to below 50 fs in the 800-900 nm range for a FY99 proposal to AFOSR.

Threshold measurements for the MVLs for multiple pulses (100) at 800 nm and 130 femtoseconds were completed in three eyes. Fiducial limits were within allowed values and only histo eyes would be required to complete the set. MVL threshold measurements for 10000 pulses at 130 femtoseconds and 800 nanometers, were completed in two eyes. The ED_{50} at thresholds were normal and the fiducial limits were within the criteria of +/- 50% of the ED_{50}. Also, exposures were started for 10 pulses to add another data point between 1 and 100 pulses.

We assisted the Air Force and their summer apprentices with an experimental setup to measure laser eye protection characteristics, particularly the "bleaching" effects produced by ultra short laser pulses.

The draft manuscript for the MVL threshold data at 800 nm and 130 femtoseconds was completed and submitted for clearance. Fluorescein angiography data from Duke University Eye Center was included.

All hardware and optics for the Mode-Locked vs. CW MVL Study were received and installed and the complete system was finalized for the study to begin in December. The MIRA 900 laser was characterized for the experiment in CW and Mode-Locked operation in preparation for the MVL experiments.

"Visible Lesion Thresholds from Multiple Pulse Near Infrared Ultrashort Laser Pulses in the Retina," a manuscript for the multiple pulse data journal (Health Physics) article, was reviewed and reformatted for submission to clearance. The manuscript "Retinal Damage from Femtosecond Near-Infrared Laser Pulses" for the macula vs. paramacula data article (Journal of Applied Optics) was reviewed and reformatted for submission to clearance officials.

Spectra-Physics delivered a Millennia V, solid-state, diode-pumped, CW laser, and a Tsunami sub-35 fs, mode-locked, Ti:Sapphire laser. These lasers replaced the I-200 argon-ion and Mira 900 mode-locked Ti:Sapphire lasers in our 100 fs Regenerative Amplifier System.

The peer-reviewed publication, "Thresholds for visible lesions in the primate eye produced by ultrashort near-infrared laser pulses," was edited in response to reviewer comments and submitted in final form for publication in *Investigative Ophthalmology & Visual Sciences.* This paper summarizes MVL work (from 7 ns to 100 fs).

Tissue from the Mode-locked/CW Experiment and Long Term Histology Study were prepared and processed for histopathology. Exposure maps, data sheets, photographs and historical information was prepared to document the experimental procedures performed on this tissue. The tissue was shipped to Dr. Toth at Duke University for analysis.

In January 2000, researchers from University of Missouri Medical School (St. Louis) and the Cleveland Clinic Foundation conducted a brief study in our lab using ultrashort laser pulses to generate bubbles in human lens tissues. This is seen as a potential remedy for presbyopia.

A series of time-based luminescence scans of a DALMX gel irradiated by RF energy were conducted while monitoring the temperature of the gel in real time. The spectroscopic study of chem-bio agents continued. We set up an LIB spectroscopy experiment to try to duplicate spectra generated by Dr. Kiel's group with RF.

Members of our group attended an AFOSR-sponsored workshop on the bio-chemistry of Diazoluminomelanin (DALM) on 20 Sep 2000. This chemiluminescent material is of importance in the bio-warfare arena.

Work on the ultrashort pulse, multiple pulse damage threshold paper (Health Physics) continued. Final abstracts were submitted to SPIE for three papers from our group and related presentations. These presentations will be given at BiOS 2001 in January.

Two papers were accepted for publication in the Journal of Laser Applications. These are related to computations of laser safety for Multiple Pulse MPEs and the classification of lasers under the ANSI Z136.1-2000 Standard. The papers are part of a series that will continue with at least three more articles, with final assembly into a book to be published by the Laser Institute of America.

Obtained eyes of recently euthanized baboons (3 adolescent, 2 fetus) from Southwest Foundation for Biomedical Research. These eyes will provide the basis for our primary RPE cell culture. We obtained all necessary reagents to make the specialized cell culture medium, including bovine neural retina.

Dr. Randy Glickman, from UTHSC, visited the laser lab on November 27 to direct a collaborative experiment. He exposed melanosomes, suspended in water, to 405 nm and 810nm laser light and measured fluorescence emission. This experiment formed the basis for his BiOS 2002 presentation.

Cell Culture: Incorporated the use of a trephine blade into the explant protocol. Trephine blades and holders provide precision cuts for explant tissue. This allowed for better quality of viability staining of explant RPE tissues using the inverted microscope, and provided reproducible sampling for experiments. A new sub-80 degree freezer was delivered to the lab for use in cell biology work.

Chem/Bio: Continued on the characterization of the Mitomycin C (MMC) induced phage from the Stern strain primarily focusing on its physiology and on optimization of high titer stock preparation necessary for molecular level studies. In addition, preliminary work was initiated on determining if an MMC inducible prophage exists in the Alls/Gifford strain. Differential expression of Edema and Lethal factor during both nominal and accelerated growth of Stern and Alls/Gifford were also continued. An abstract for the DARPA Workshop on "Molecular Electronics and Chemical and

Biological Agent Detection" was prepared and submitted. The abstract was accepted for presentation.

Skin/Cornea (1314nm): The protocol for the skin spot size study was submitted for amendment such that each animal may receive up to 72 exposures per side, and such that one pig can be sacrificed for collection of skin samples by the UT Austin team (IRAD collaboration with Northrop Grumman).

Acute 810-nm exposures of RPE cell cultures: A modification of the optics train from the Mira laser to the cell exposure stage improved resolution at very low energy levels at the cell sample. With this modification in place, titration continued of CW and mode-locked laser irradiance causing damage in hTERT-RPE1 cells containing either bovine or baboon melanosomes. Multiple methods (employing a Mitutoyo microscope objective and the new ORCA CCD camera) were used in an attempt to obtain accurate counts of melanosomes. O.D. spectra of solutions containing melanosomes of varying concentrations were also obtained from both bovine and baboon sources.

2.6. Safety Standards for Optical Systems: USAMRD Support

Scope: Provide professional and technical assistance to characterize the biomedical effects and implications of laser exposure on biological tissue and develop and evaluate treatment regimes. Provide services to the U.S. Army Medical Detachment of the Walter Reed Army Institute of Research (USAMRD-WRAIR).

Significant Activities

This task order supports United States Army Medical Research Detachment (USAMRD) research on biomedical effects and treatment of laser injury. Project management and professional consultant support are provided in the areas of: infrared laser ocular effects, evaluation of Nerve Fiber Layer (NFL) degeneration following acute laser-induced retinal damage, new optical imaging approaches for detection of laser ocular damage, clinical evaluation of victims of accidental laser eye injuries, evaluation of treatment regimes to minimize laser-induced retinal damage, and testing of ocular protection provided by optical limiting switches. The latter item is being studied at USAMRD facilities under a CRADA agreement between TASC and USAMRD. Technical assistance for the above projects and other USAMRD research efforts is being provided by TASC employees working in the general areas of laser optics, optical radiation measurements, anesthetized subject preparation and handling, and ocular tissue preparation for pathological evaluation.

During June 1998, a paper on IR laser eye effects was published (Journal of Laser Applications) and a paper on optical switch work was presented at the First International Conference on Optical Power Limiting. Work was completed on the final experimental phase of the optical switch contract effort, a study of retinal damage threshold dependence on retinal spot size for nanosecond duration pulses. The final report was completed for the optical switch contract. The material on retinal damage threshold dependence on spot size was formatted for presentations and proceedings papers for the BiOS '99 and ILSC '99 meetings.

The spot size study is the only phase of the optical switch work that the UK DERA has approved for public release.

An experimental protocol on "Ocular hazards from high-power infrared lasers" received final approval (Protocol number HEDO-99-03) and lab set-up has begun. This project is a collaborative effort between USAMRD, USAF HEDO and TASC with the experimental work split between the AF and USAMRD laboratory facilities at Brooks AFB.

Dr. Brian Lund provided software support for the Laser Accident and Incident Registry (LAIR). He also developed a software package to present researchers with a user-friendly interface to the database and to offer several analysis tools that can be applied to the database. Dr. Lund also provided general support to other USAMRD projects in areas relating to physics and mathematics. He developed an algorithm used to calculate retinal irradiance from a Gaussian laser beam based on data from the eye-movement study and is a co-author on the ILSC proceedings manuscript.

The 1.314nm pulsed laser was delivered and the IR experiment lab set-up was basically completed. Rhesus subjects were screened in preparation for the first experiments. Screenings included SLO and OCT examinations of several subjects for baseline recordings. The subject that had received the 1315nm test exposures resulting in ~12 ophthalmoscopically visible retinal lesions was examined by SLO and OCT imaging at USAMRD facilities. The results demonstrate the unique "full-thickness" retinal damage effects associated with this particular wavelength band. Data collection for the retinal damage thresholds from the 1.3nm laser was completed and macular and paramacula thresholds were determined (~350 mJ in each case). SLO and OCT imaging of 1.3nm laser- exposed eyes was carried out. The final exposed subject was sacrificed for histopathologic evaluation of the laser-induced damage.

Following completion of the primate retinal threshold determination for 1315nm pulses, the laboratory was reconfigured for assessing corneal/lens effects from the same laser in rabbit subjects. Modifications were required to the multi-degree of freedom animal stage used for delivering laser exposures in primates. The fundus camera was replaced with a slit lamp for corneal/lens observations and a separate animal stage (also configured for mounting rabbits instead of monkeys) required for use with the slit-lamp for observations and photography.

The 1315nm corneal/lens study proceeded. A preliminary estimate of the corneal damage threshold is .4 J for a 1 mm corneal spot size. Lens effects were only seen with the highest pulse energy available and the lens threshold appears to be >2x the corneal threshold.

An experimental protocol for the follow-on optical switch project (to be conducted in Army laboratory facilities but funded through a different contract vehicle) was prepared and submitted for the in-house review process. This protocol would extend the retinal threshold vs. spot-size study and provide additional input for revising the extended-source laser safety standards as well as provide empirical data toward validating the theoretical model predictions of eye protection afforded by optical switch devices.

The HEL bio-effects experiments resumed using a cw Nd:YAG laser with emission at 1.318 nm. The initial experiments directed a collimated beam to the eye with ~5 mm beam diameter incident at the corneal plane. First rhesus and then rabbit eyes were exposed to the full beam power (~2 watts) for exposure durations ranging from 1-20 sec to determine exposure time required to induce a retinal effect. No retinal effects were found in the rhesus. In the rabbit eye, minor retinal disruption was noted only with >10 sec exposures, and then only at ~24 hr or more post-exposure. These results are consistent with work done in this lab 5-6 years ago using the same laser. Emphasis will now shift to determining cornea/lens thresholds using 10-sec exposures to the laser. Only rabbit subjects will be used for the anterior ocular tissue studies.

Work continued on the LAIR database. Data entry was provided via an inter-agency agreement with HSIAC (formerly SERIAC).

The experimental effort on the new optical switch project was begun. The first experiment was to determine the collimated beam (baseline) threshold ED50 for the Q-switched doubled Nd:YAG laser. This will anchor the threshold vs. spot-size data that will follow for extended-source but otherwise identical exposure conditions.

Work on the lens fluorescence project continued with photometric and radiometric measurements of the fluorescence induced in human (eye bank donor) lenses by UV/blue light at exciting wavelengths from 350-450nm.

Experimental data collection on the lens fluorescence project was completed as of the end of February. The previously described sequence of photometric and radiometric measurements of the fluorescence induced in the lenses by UV/blue light at exciting wavelengths from 350-450n was conducted for each lens. Data analysis and report preparation continued through the summer.

Preliminary work continued on the next phase (annular beam profile threshold study) of the UK DSTL contract. Animal subjects were screened and the nine rhesus subjects required to complete the proposed work were assigned to the protocol.

A manuscript based on the results of the eye movement studies was prepared and submitted to Health Physics with Dr. Lund as the first author. Dr. Lund is working on a computer program to model heating of the retina by a laser beam moving across the retina in a manner simulating the motion pattern revealed by the eye movement studies.

Data analysis was completed on the UK annular beam profile study in February 2003. A report was submitted for export clearance and delivery.

Installation of the 1.315nm, Q-switched laser was completed by the manufacturer. The experimental work will be conducted under the IR wavelength-dependence protocol. Six animal subjects were screened and four accepted for use on the protocol.

2.7. Safety Standards for Optical Systems: US Navy Support

Scope: Provide research and research support to the Naval Medical Research Institute Detachment at Brooks AFB to investigate the impact of optically directed energy on the health and safety of military personnel. General tasks included: a.) experiments to understand the human visual system and its susceptibility to sources of optical radiation in military operating environments, b.) modeling human and non-human primate visual system performance and its susceptibility to optical radiation events, and c.) the development of computer-based hardware and software which simulates optically directed energy effects for the purposes of military mission planning and mission rehearsal.

Significant Activities

This Task Order was awarded on 15 January 1998. The work performed under this Task Order included: integration of a Matrox CCD camera with LabView COTS software for image manipulation and data scoring at the Naval Medical Research Institute (NMRI); eliciting future work requirements necessary to support human-use search experiments under laser exposure; and providing support to an interservice working group.

TASC personnel worked with NMRI personnel to instrument a human-use glare field detection and search study. TASC personnel worked with NMRI personnel in an IPT capacity to instrument the experiment and develop a LabView Virtual Instrument "Plug-In" to work with the Cambridge Research Visual Stimulus presentation system and system software. The quality of the Landolt-C stimulus produced by the Visual Stimulus Generator (VSG) was evaluated and it was determined that the Barco projection monitor could produce a marginally acceptable stimulus at the smallest required size (gap size of 1 minute of arc at a subject distance of 3 meters). The quality of the stimulus at smaller sizes becomes poor due to the pixel size versus image size ratio getting larger.

Custom software was written to perform the contrast sensitivity testing using LabVIEW in conjunction with the VSG to generate the Landolt-C stimulus. The software requirements were specifically determined, to include how the testing parameters would be input, the exact threshold determination method, the contrast/luminance relationship, and the output required.

LTAMPS, as currently configured, can work with DTED and ADRG Tactical Pilotage chart data produced by NIMA. This information is in the form used by other squadron-level mission planning and intelligence applications, and should enable LTAMPS interoperability with other applications as the geo-spatial information is common.

The current state of the LTAMPS port was demonstrated on 27 July 1998 at the TASC Koger Center office. Delivery of the final version of LTAMPS was scheduled for the end of August. The Fallon Range satellite imagery from NIMA is on order and will be integrated with the DTED terrain package. The integrated imagery, terrain data and LTAMPS software will be used to support mission planning and rehearsal, and the playback of the H-60 test data planned for November 1998.

TASC incorporated the Fallon Area NIMA imagery into a format compatible with LTAMPS. The NIMA satellite imagery was rendered on top of the NIMA vertical data with success. LTAMPS now has the capability to produce realistic looking terrain for the Fallon NAS training ranges. In addition, the capability to calculate line-of-sight "rings" on the ground has been incorporated into LTAMPS. This was accomplished by 1) providing a stand-off or slant range from a specified position, 2) identifying maximum altitude and 3) a minimum altitude from which line-of-sight openings to the surrounding terrain are calculated and rendered with different colored rings. Results look extremely realistic and promising. They will be useful in determining beam backstops and flight path waypoints for the Fallon flight test, scheduled for 7-18 December 1998. This line-of-sight calculation application and the NIMA-rendered texture mapping onto NIMA Digital Terrain Elevation Data (DTED) both work with raw data as provided by NIMA and has application for all regions where NIMA has the data, which is most of the world. This capability, due to its ease of use with raw NIMA data, is useful for many other applications as well as its intended purpose of forming the basis for a Tactical Decision Aid (TDA) for mission planning and rehearsal for missions where hand held anti-personnel lasers may be encountered.

The integration of angle information derived from Tri-pod angle encoders is a concept that uses the azimuthal and elevational measurements derived from the Tri-Pod system, coupled with LTAMPS capabilities to "zero" or otherwise calibrate, align, or affix the position of the Tri-Pod on the mapping system that LTAMPS uses. This leveraged software that has already been developed provides for a consistent and cost effective solution to interelate Tri-Pod derived angle information with timing information and TACTS provided SH-60 time, space and position information. These encoders, which work with LabView boards and associated software, measure the azimuthal and elevational displacements from a "nulled" position in increments of 50 microradians. The approach, using this system to establish locations on the range, was used in a test conducted in January 1999 to measure the evening background ambient light in a method comparable to that done during the ground test, but with the EH-60 engine operating and with those avionics powered up and operating that are expected to be in use by the SH-60 during the flight test. The test was conducted and the readings of the background ambient luminance were consistent with those measured at Martingdale AAASF during the ground test, which established cockpit irradiance levels for the flight test. The ambient background irradiances measured with the UH-60 powerplants operating did not significantly differ from those same measurements made from generator power. The instrumentation was not effected by any EMI in the UH-60, and was found suitable for flight test.

It was learned that it will be necessary to leave the flight test instrumentation unpowered until the UH-60 is operating from powerplant-generated electrical power. During the test it was found that transient electrical conditions resulting from switching the aircraft power from auxiliary-generated power to powerplant-generated electrical power caused an intermittent and potentially damaging spike of power to propagate through the aircraft. All aircraft lighting fluctuated during this time, indicating unstable electrical conditions which could be hazardous to the flight test instrumentation. The SH-60 to be used at Fallon NAS for the test may likely exhibit similar characteristics and it is recommended that the instrumentation be powered-on only after the SH-60 is using powerplant-generated electrical power. This will ensure that the instrumentation will be protected from any transient surge in aircraft voltage.

Extensive measurements were made of the UH-60 aircraft instrument illuminances. This data will be used for the psychophysical tests to be performed during conditions of laser illumination during the flight test. This data will be delivered before the flight test.

2.8. Protection against Optical Systems: LEP Research

<u>**Scope:** Provide research and research support in the area of protection against optical sources. General tasks included tests of optical quality, tests of physical properties, and laboratory psychophysical vision tests with human subjects to assess the effects of various laser eye protection (LEP) devices. Tasks also included performing aircraft simulator, ground, and flight tests of LEPs to assess operation effectiveness. Animal research to demonstrate the protection capabilities of protection devices was also required.</u>

Significant Activities

ALFA

Rugate spectacles obtained from Rockwell were returned to WL/MLPJ without being evaluated because they were not representative samples of eye-centered rugate LEP. Anthropomorphic data were obtained from the CARD lab at Wright Patterson AFB and analyzed as the first step in defining eye locations in relation to angular-dependent LEP.

The report documenting the laboratory evaluation of three different configurations of ALFA holographic spectacle samples was completed. The TR documenting the laboratory evaluation of two early holographic spectacle samples was published as AL/OE TR-1996-0050. Optical and spectral transmittance data were collected for the British SLAP, LABLES and ABLES spectacles. Miscellaneous LEP samples were measured, including a blue green eyepiece from Edwards AFB, UVEX "eye armor", and Tactical Goggles from Bolle.

Abstracts were submitted to the American Academy of Optometry for the following topics: Modeling the Trade-Off between In-Band Laser Eye Protection and Color Confusions; and Discriminating Laser Eye Protection On The Basis of Regan Contrast Letter Acuity Scores. An abstract was submitted to the SPIE on Color shifts in a phosphor display with laser eye protection: LICOM 1.

Development and coordination of the statement of work for the LICOM II work with Mobium Enterprises (formerly Nascent Technologies) continued.
The CSI and FM100 data were collected on the Pilkington TTL dye spectacles with five levels of optical densities between 2.0 and 4.0 at 532 nm. The Regan Acuity and Howard Dolman data collection for the five levels of optical density samples was completed.

WAR DOVE
Fifteen WD1 and ten WD2 WARDOVE visors were delivered in September 1997. Some of the visors had noticeable delaminations. Nine visors, three of WD1, WD2, and FV-9 visors, were optically tested and prepared for flight evaluation. One of the WD1 visors had to be replaced because of delamination. Twenty-four visors, eight of each type, were tested and put into use in vision and flight evaluations. Three hundred FV-9 wraparound spectacles were received from Dalloz Safety (Glendale). Optical quality, spectral, and laser density measurements were completed on ten samples from each of the three lots. Additionally, evaluations of the WD1, WD2 and FV-9 spectacles were performed in flight simulators at Holloman AFB (F-117) and at Seymour Johnson AFB (F-15E).

FV-9 wraparound spectacles were shipped to the US Navy at NAS Oceana for flight evaluation. One pair of FV-9 wraparound spectacles was provided to AFSOC, Special Tactics Group. Preparations were made and coordinated for flight evaluations of the WARDOVE visors at Nellis AFB, Holloman AFB, and Seymour Johnson AFB. Contacts were made and letters were prepared requesting support for LEP evaluations by AMC and AFSOC.

The AMPS II mount was used to position the WARDOVE visors to perform the power, prism, and distortion measurements at the required nine locations. The AMPS II mount continues to be used in the laser densitometer for positioning and aligning spectacle and visor samples for proper laser density measurements. The AMPS III mount is used to perform optical quality measurements in the current optical quality measuring instruments and in the PEATS. Final revisions to the AMPS operating and maintenance manual were made. The design of the new filter wheel mechanism for the laser densitometer was completed. Integration of the AMPS III mount and other improved control and detector electronics with the laser densitometer was completed. The machined parts for the new filter wheel assembly were integrated with the laser densitometer. The new photomultiplier (PMT) detector and cooler housing system were also integrated with the laser densitometer. The control software for the new laser densitometer configuration was developed and debugged. The modifications to the laser densitometer and the control software allow the positioning of the samples to be controlled by the AMPS III mount while the data collection is performed. The new configuration of the laser densitometer permits much faster and more reliable measurements of optical density, especially for reflective samples that have angular and positional dependence.

Initial plans for the laser eyewear vision evaluation laboratory (LEVEL) were made. A 532-nm laser was ordered from Spectra Physics. The optical bench and optical/mechanical hardware for the laser eyewear vision evaluation laboratory (LEVEL) were identified and ordered. Definition of the beam projecting optics was begun. The protocol for the laser eyewear vision evaluation laboratory (LEVEL) was completed and approved by statistical and medical (informal) reviews. The protocol for the laser eyewear vision evaluation laboratory (LEVEL) experiments was presented to the Human Use committee on 3 March 1998. The protocol was approved by the ACHE as minimal risk.

The protocol for flight evaluation of WARDOVE spectacles and visors in AMC and AFSOC aircraft was presented to and approved by the 3 February 1998 ACHE.

The draft report documenting the vision testing of the WD1, WD2 and FV-9 WARDOVE visors at the vision testing facility at Randolph AFB was completed.

A program review for the Pilkington Optronics LEP efforts was held on 13 and 14 January 1998 at Brooks AFB. Representatives from Pilkington Optronics, Pilkington Aerospace, Baush and Lomb, AFRL/MLPJ, AFRL/HEDO and TASC attended. The status, progress and plans for the past contract and the current contract were presented and discussed. The physical measurements, vision evaluations, and simulator tests of the WARDOVE samples performed by TASC and HEDO were presented.

The last ten WD1 visors were received from Pilkington. This completed all of the required deliveries of LEP under the initial contract. Nineteen of the visors, 8 WD1 and 11 WD2, were returned to Pilkington for replacement. Pilkington agreed to replace these visors since they were delaminated when received. During April 1998, twelve of the nineteen visors that were returned to Pilkington for replacement were held by U.S.Customs in Houston. There was a Customs problem related to the original return shipment of the visors by ASG USA to Pilkington. TASC took action to resolve the problem and the visors were released by Customs.

The final report of the optical and vision evaluation of the WD1, WD2 and FV-9 Spectacles was reviewed, revised and submitted for publication. The TR documenting the eyebox study using anthropometric data from the CARD database was completed and submitted for publication. The report documenting the tests of the FV-9 and FV-6MR wraparound spectacles performed by the A-10's at Nellis was completed.

Nine pair of FV-9 wraparound spectacles were shipped to the 422 TES at Nellis AFB for use by the F-15 pilots in conjunction with the ACP-2.

Conducted vision evaluation of the five pair of spectacles with different concentrations of the Pilkington TTL dye (2.0, 2.5, 3.0, 3.5, and 4.0 optical densities at the 532 nm line) as well as of the most recent Kaiser holographic spectacle.

The WD1, WD2 and FV-9 spectacles were used to view the instruments in a C-130J simulator at Lockheed Martin Aerospace Systems in Marietta, GA. The WD1 and WD2 spectacles were judged to be significantly better than the FV-9.

Rockwell Science Center was given contractual authority to begin the effort to improve and deliver rugate LEP samples.

A contract with AOtec Inc. to develop a wraparound spectacle frame and to fabricate a mold for 8 diopter lens blanks and caps suitable for dielectric coating was initiated. A kickoff meeting was held on 24 March 1998 and five different styles of wraparound frames were selected for prototyping.

A contract was initiated with University of Dayton Research Institute (UDRI) to define the size, type and velocity of particles expected to be in aircraft cockpits that experience a birdstrike.

LEP Assessment Methods and Systems

Mobium Enterprises submitted the final revisions of the LICOM II software and the user's manual. The Phase 2 follow-on work to expand the computer program to handle both colored reflective surfaces with varying illumination and color shifts under mesopic conditions, as well as providing a compiled (as opposed to interpreted) version for more general distribution of the model was held pending the availability of funding.

Work on the Protective Eyewear Automated Test System (PEATS) continued with the integration of the motorized wheel to hold Ronchi rulings and a fiber optic assembly for measuring prism. Development of the software to control the AMPS in conjunction with the PEATS camera control and data collection continued. Initial evaluations of the configuration needed to perform prism measurements were performed. Initial indications are that prism measurements can be made to a precision of .025 diopters. A fiber optic mount for the motorized wheel was designed and fabricated. The investigation of other instruments for performing the spectral measurements continued. The possibility of applying for a patent for the PEATS was discussed with a representative from the JAG office. It was determined that the final report, published for the previous TASC contract, constituted disclosure of the PEATS and thus a patent cannot be obtained. Development of the software to control the AMPS in conjunction with the PEATS camera control and data collection continued. Work continued on the LabView software to collect data and to input the measurement configuration to PEATS. Various methods were explored for reducing the Ronchi pattern data to determine distortion. Some difficulties were encountered with the stability of the images produced by the CCD camera. Work on PEATS to automate the optical evaluation of LEP is a continuing effort. The level of work on PEATS was reduced in order to concentrate on set up for the side-shield experiments and planning for the scripted LEP and clip-on evaluations.

The LEP vision evaluation system consisting of four diodes (red, green, blue and white) and methods for using this system to assess the multiple images that occur with reflective LEP was developed. This system is referred to as the Multi-Point Light System (MPLS1). Pilot studies of different eyewear and methods of collecting data from the MPLS1 were performed. Analysis of the MPLS1 guided the construction of an arc type point light source device to measure field angle dependence of the multiple images (MPLS2). The MPLS2 is used to do laboratory and field assessments of the multiple reflections in LEP. A device is available with different colored gumballs that illustrate the color confusion that can occur with certain LEP devices.

A task to build and deliver an Automated Mounting and Positioning System (AMPS) to the US Army (CHPM) was received and work to identify and acquire materials was begun.

Manufacturability, Affordability, and Supportability
Pilkington Optronics performed coating trials with the 8-diopter base curve lenses produced by AOtec. The issue of the 6 diopter versus 8 diopter base curve lenses for reflective LEP remains an issue. This issue was addressed with MLPJ and Rockwell.

The University of Dayton Research Institute (UDRI) report documenting the size, type, and velocity of the fragments produced by bird strikes on canopies was published as a TR.

The mold for making 8 diopter caps and bases was completed by AOtec. Problems were found with the insert for the base lenses. This insert was reworked. A small production run of the caps, which are used to apply the dielectric coating, was made. Sample 8 diopter caps were provided to Pilkington so that they could begin coating trials.

The report documenting the study of variability of FV-9 wraparound spectacles entitled Assessment of the Physical Performance and Manufacturing Repeatability of FV-9 Laser Eye Protection (LEP) Spectacles was published.

Spectacle Frame Development
Two more of the five prototype LEP wraparound frames being developed by AOtec were received, bringing the total to four out of five. All five must be received before a comparison and down selection can be accomplished. AOtec has been late in delivery of these frames. Other potential sources for wraparound frames were investigated, including Wilson (Glendale) and Artcraft. Discussions continued with AOtec related to the completion of the contract for development of wraparound frames. The environmental testing of the frames that is required under the contract is not considered necessary, since the frames will not be used for LEP.

Discussions continued with Dalloz Safety related to the molding of side shields for the Artcraft Aircrew frame using the FV-9 or FV-6MR LEP dye material. The Artcraft Aircrew frame and a set of side shields that were modified to be compatible with the helmet and visor were sent to Dalloz Safety.

The statement of work to obtain side shields made from laser protective material for the Artcraft Aircrew Frame was coordinated and revised.

The AOtec effort to produce a mold for 6-diopter lens blanks for reflective and prescription LEP continued. The designs for the 6-diopter caps, thin bases, and thick bases were revised to reflect the nominal pantoscopic tilt and face form angles for the IAS frames.

The subcontract effort to obtain side shields made from laser protective material for the Artcraft Improved Aircrew Spectacle (IAS) frame continued at GPT/Glendale. The final SLA prototype side shields were produced and delivered. The final SLA prototype side shield was used to make a mold for casting polyurethane side shields that can be tinted. These early prototypes were used for vision evaluations of side shield with variable transmission.

The AOtec effort to produce a mold for 6-diopter lens blanks for reflective and prescription LEP was completed. After a very long delay in the fabrication of the injection mold, AOtec produced and delivered 2mm thick base lenses, 1.5 mm thick cap lenses and 11mm thick base lenses for use with reflective LEP. A request to use the mold to support a Navy program was approved. The work to initiate a contract with AOtec to produce clip-on frames for the IAS spectacles was stopped and AOtec was told that no further action on this effort would be taken.

The Brooks Optical Research Unit ground and polished 11mm thick base lenses to an approximately -6 D script. They had difficulty in achieving the exact script desired. The processes and equipment used to produce these lenses were examined and adjusted. Several 1.5mm cap lenses were laminated to 11mm bases and provided to the Brooks Optical Research Unit. These laminated lenses (without the expensive LEP dielectric coating) were used to demonstrate scripting before the scriptable LEP lenses arrival. Two pair of laminated lenses were successfully ground and polished. These lenses were hard coated and trimmed to fit the LAS frames.

The subcontract effort at GPT/Glendale to obtain side shields made from laser protective material for the Artcraft Improved Aircrew Spectacle (IAS) was completed. Glendale produced and delivered 500 pair of FV-9, 250 pair of FV-6MR, 250 pair of FV-6 and 500 pair of clear side shields. The FV series side shields are currently being used in the side-shield vision experiments.

The Optical Research Unit (ORU) was contacted to begin arranging the production of scripted spectacles in LAS frames for use in the laboratory and field evaluations of clip-on and scripted LEP. The scripts for individuals who participated in the laboratory evaluations were provided to the ORU.

Fifty CLEPIR spectacle kits were received from Thales Optics. Each kit includes one LAS frame, two CLEPIR (WD1A) lenses, a spectacle case and a cloth storage bag. The WD1A lenses in these kits are untrimmed and will be used to mount in the clip-on frames. These kits were delivered under the 311th HSW/YA contract with Thales. The lenses have been inspected and measured. Ten pair of these lenses have been edged and mounted in the clip-on frames produced by Randolph Engineering. More lenses will be mounted as required to support the field evaluations.

The accelerated program to develop and produce a clip-on frame that fits the Laser Aircrew Spectacle (LAS) frame was completed. Randolph Engineering, under a Northrop Grumman subcontract, delivered 50 pair of clip-on frames for the LAS. This clip-on frame is available from Randolph Engineering as part number LC04. Vibration and acceleration testing of the clip-on frame attached to the LAS frame was conducted. The clip-on frame stayed in place under all of the very rigorous vibration and acceleration tests. Fifty spectacle cases that were especially designed to hold and protect the LEP clip-on and the LAS spectacle were received from Randolph Engineering.

LEP Physical and Vision Assessments

The vision evaluations of the Pilkington TTL dye spectacles with five levels of optical densities between 2.0 and 4.0 at 532 nm continued. The CSI testing and the Regan acuity and FM 100 testing is complete. The Howard Dolman tests were delayed due to malfunctioning of the apparatus.

The data from the F-15E flight tests of the WD1, WD2 and FV-9 visors at Seymour Johnson AFB was reviewed. Since the number of sorties that were flown was less than planned, it was decided that further data would make the evaluation more complete. Arrangements to complete the data collection were completed and further flight evaluations will take place at Seymour Johnson AFB.

Initial experiments and trials with a flight simulator type computer program were conducted to devise a method for investigating the headache/eyestrain problem with the WD1 visors identified during flight tests.

Coordination of the planned tests with AMC and AFSOC continued. A visit was made to Little Rock AFB to examine the C-130 simulators and Computer Based Training (CBT) devices. The test request for AFSOC fixed and rotary wing aircraft was written. A version of the LEP questionnaire was developed for C-130 loadmasters.

Efforts were made to identify and isolate the small bias (.13 OD) in the laser densitometer measurements. The bias has been traced to the use of the 8 OD filter during the nulling operation. Absorbing material and baffles were added to the laser densitometer to reduce potential reflected stray light problems.

Visual screening was performed on the different configurations of the dielectric and dielectric/dye spectacles produced by Pilkington Optronics under the current WARDOVE program. The multiple reflections, back reflections, haze and cosmetic properties of the samples were assessed. It was found that the use of an anti-reflection (A/R) coating greatly reduced the multiple reflections. The overcoating of the dielectric layer resulted in an improvement over the laminated samples, but the overcoating process needs to be improved. It was decided that the WD1 spectacles with A/R coating would be designated as WD1A and would be assessed in comparison with the WD1 spectacles.

Four FV-9 and four FV-6MR visors were measured for optical density at 1064nm and were shipped to Holloman AFB for use in a flight program involving a chase aircraft and the F-117 laser designator system.

Commercial LEP spectacles used by individuals at Kirtland AFB for protection in operation of the chemical oxygen iodine laser (COIL) were evaluated.

A double aperture method for calibration of the Varian Cary 5 spectrophotometer was assessed. This procedure will potentially provide a method for certifying the accuracy of the spectrophotometer on a routine basis.
Glare data collection for the FV-6, FV-6MR and FV-7 spectacles continued. Planning was started for the vision evaluations of in-band protection, including the

Pilkington dye and dielectric spectacles(DADS), the Rockwell rugate filter spectacles, and the holographic spectacles.

Work to prepare a Vernier acuity task for use in LEP vision evaluations was begun. The display system (Vision Probe) that was originally planned for use in this task was not functioning due to hardware failures. An alternate system (VERIS) was investigated for possible use.

The data analysis of the C-130 simulator tests of the WD1, WD2, FV-9 and clear lens spectacles continued. Further C-130 flight assessments were scheduled to complete the flight test data collected in November at Little Rock AFB. Ground and flight assessments of WARDOVE LEP in the C-17 and C-141 aircraft at Charleston AFB were completed.

Work was started to incorporate the 5W 532nm laser in the laser densitometer. The more powerful 532nm laser will permit illumination of the entire lens of LEP spectacles for laser density measurements.

Physical testing was performed on the 7 WD1A and 17 WD2A spectacles received from Pilkington last month. These antireflection-coated spectacles were prepared for use in future flight testing.

Physical measurements were made on the twelve improved WD1 visors and 14 pair of 8-diopter base curve wrap around spectacles in the Wilson Prevail frames that were received from Pilkington. The improved visors have a thicker cap so as to reduce the distortion in the cap that results from the stresses induced by the dielectric coating. This should result in a better bond between the cap and the base and thus reduce the delamination problem previously experienced with WARDOVE visors. We observed no delamination of the improved visors yet.

Representatives from AFRL/MLPJ and Rockwell Science Center came to Brooks AFB to discuss and assist in the edging and mounting of the eye-centered rugate filter lenses in aviator spectacle frames. One pair of lenses was measured, fitted and mounted in frames at the Brooks optics lab. The remaining lens will be mounted, edged and will provide samples for physical, vision and flight evaluations.

Development and evaluation of the LabView software to control the CCD camera for the PEATS continued. The PEATS system has not been reassembled since the move to the DEL. The PEATS camera was operated to begin calibration for measurement of the optical signature of reflective LEP. The window for the CCD detector was cleaned to eliminate artifacts found during the calibrations.

Data analysis of the glare data for the FV-6, FV-6MR and FV-7 spectacles using the Brightness Acuity Tester (BAT) continued. This data was compared to the previous results of haze effects on Regan variable contrast.

Vision evaluations of the Pilkington dye and dielectric spectacles (DADS) were completed. The in-band evaluations will continue with the Rockwell rugate filter spectacles and the holographic spectacles. The five pair of rugate filter spectacles, received from Rockwell, underwent physical evaluations.

Elimination of the Howard-Doleman stereopsis and the PIP color charts tests from the standard battery of vision evaluation tests for LEP was recommended due to the complete lack of performance discrimination that these tests provided for LEP evaluation.

Several members of the HEDO LEP team spent the week of 14 June at the Air National Guard and Air Force Reserve Test Center (AATC) Tucson, AZ collecting data for LEP compatibility with NVGs and the Air Commander's Pointer in the F-16 and O/A- 10 aircraft. The aircraft were placed in a hanger to control lighting conditions while the team collected vision acuity data with NVGs with and without LEP. Windscreen and canopy scatter data was measured using several types of hand-held laser pointers.

The revised proposal from Pilkington Optronics and Bausch and Lomb for the continuation of the WARDOVE effort was received. The proposed tasks and estimated costs for the WARDOVE Phase 4 effort were reviewed and Pilkington was directed to re-scope some of the tasks to remain within available funds.

Direction was provided to Pilkington to define the specific numbers of samples and frame types for the spectacle samples to be delivered to complete the WARDOVE Phase 3 contract. Pilkington received quotations for the different items required to complete the Phase 3 effort and submitted a proposed delivery schedule. The proposed delivery schedule was dictated by the availability of the specified frames. Pilkington contracted with Artcraft Optical for 250 Aircrew spectacle frames for mounting WARDOVE LEP. The $3900 tooling costs for reestablishing the ability for manufacturing the Aircrew frame was included as part of the acquisition of these frames. Pilkington will provide three types of LEP, including WD1A, DADS3, and WD4 (red laser pointer protection), in five different frames. Lens blanks of the different LEP filter types will also be provided for AFRL edging and mounting tests.

Physical evaluation of the rugate filter LEP lenses provided by Rockwell was completed. Optical density at 532nm was measured at different locations across the lens. Laser density measurements were made on lenses rotated about the eye center location and rotated about the surface of the lens.

The development of the Protective Eyewear Automated Test System (PEATS) was re-initiated. The initial evaluations determined the spectral measuring capabilities of the system. The PEATS camera was mated to the spectrograph. The most recent version of the spectral data collection software was obtained and installed. Assessing the basic performance of the CCD camera in terms of data orientation, uniformity of response, and cross talk between pixels was done.

Pilot experiments were performed in the LEVEL using laboratory personnel as subjects. The hardware and software functioned well. These initial tests characterized the protection/acuity tradeoffs of the graded Pilkington dye series LEP (2.5- 4.0 Optical Density –in .5 OD steps). Preliminary runs were completed in a study comparing performance of the Kaiser holographic (K9192), the Rockwell rugate filter (R00S1) and the Pilkington DADS3.5 spectacles. Demonstrations of the LEVEL facilities were conducted for several groups of Air Force visitors.

Methods of assessing color and depth perception to replace the Howard-Doleman stereopsis and the PIP color charts tests were selected. Pilot testing of the color-matching test for the CSI was completed with three subjects. The target detection test to investigate the contrast ratio changes caused by LEP was conducted with red figures on green background.

The Humphrey perimeter has been modified to investigate detection with in-band LEP devices. A green filter provides a narrow band source for the perimeter. Data was collected to determine the protection distribution provided by eye-centered rugate and holographic LEP. These investigations were performed in preparation for the off-axis exposure experiments in the LEVEL facility.

The Field Of View Experimental Apparatus perimeter ("FOVEA") was used to measure and compare the relative coverage of different candidate LEP frames. Eight candidate frames, including the new aircrew frame with and without side-shields, were tested with one subject. Further data was collected to include more subjects and to examine the effect of face shape and the fit of the frames on field of view. Digital pictures were taken to document the fit of the frames.

The CARDlab anthropometric data was analyzed to determine the normal variation expected in face shape and the resulting side protection requirement. Anthropometric measurements were taken on several in-house personnel to determine the comparison of specific measures made by HEDO to the wider population included in the CARDlab database.

LEP assessments with the Air National Guard and Air Force Reserve Test Center (AATC) Tucson, AZ are ongoing. F-16 flight assessments of laser pointers, NVGs and LEP will continue. Plans for in-flight LEP assessments with the Air National Guard and Air Force Reserve Test Center in Tucson, AZ were completed. We sent another three FV-9 Santa Cruz wrap around spectacles for the in-flight evaluation portion of the study to be used for the actual hand-held laser portion of the test. Initial feedback from the F-16 tests indicated that the FV-9 is a little too dark. The AATC test director requested that WD1 LEP be provided in wraparound spectacles if possible. Three different formats of the WD1 wraparound spectacles are being considered for possible use in these tests. Only a few wraparound WD1A spectacles exist. The WD1A wraparound spectacle samples were produced in the OFS, Awesome and Prevail frames as part of the 8-diopter wrap around spectacle program. The WD1A wrap around spectacles must be assessed for angular field of coverage and for angular protection prior to use in actual laser pointer tests.

Physical evaluation of the rugate filter LEP lenses and the five pair of spectacles provided by Rockwell continued. Analysis of the spectrophotometer and laser density measurements also continued. The complex nature of an eye centered filter is evident from the evaluations done to date. Other, more direct, methods of measuring the protective properties of eye-centered LEP were being investigated.

The evaluations of the spectral measuring capabilities of the Protective Eyewear Automated Test System (PEATS) continued. The assessment of the basic performance of the CCD camera in terms of data orientation, uniformity of response, and cross talk between pixels continued. Data was collected and spectral wavelength calibration data analysis was performed. An apparent lack of sensitivity in the red and NIR regions was investigated. Calibration of the amplitude of the signals from the different portions of the spectrum has been unsuccessful to date.

Data analysis of the vision evaluations of the Pilkington dye and dielectric spectacles (DADS) continued. The vision performance data collection for the R20SA rugate spectacles continued with the color vision tests (CSI and FM-100). The rugate LEP was evaluated with the color matching and target search tasks. The evaluations of in-band LEP continued with holographic spectacles.

The collection and analysis of the Regan glare data to quantify the effect of haze in the glare and no glare conditions continued. Additional haze sample (1%, 5%, 10%, 15%, 20% and 30%) data was collected and additional subjects were tested for inclusion in the revised technical report titled "Discriminating Laser Eye Protection on the Basis of Regan Contrast Letter Acuity Scores".

The Phase 4 WARDOVE program was severely impacted by the decision of Luxottica, the parent company of Ray-Ban, not to participate in the program to bring the Pilkington Optronics dielectric LEP coating process to an on-shore production facility. This decision essentially prohibited the performance of two of the major tasks that had been defined for the Phase 4 WARDOVE program. Pilkington Optronics will have to conduct a search to see if another acceptable on-shore source can be found. The efforts to establish an on-shore production capability for the Pilkington dielectric LEP that were being performed under AFRL/HEDO sponsorship will be conducted by the Title III program. The Title III program is just beginning. The availability of an on-shore production capability for the Pilkington dielectric LEP will be delayed by approximately one year. Action was taken to divide the Phase 4 WARDOVE program into two parts. One part consisted of tasks to be performed by Pilkington alone, and the other part included tasks that would have involved Ray-Ban. This division of contractual efforts permitted us to proceed with the work related to the ABL LEP and the scripting of dielectric LEP. The contract with Pilkington for these efforts is in place and work has begun. The funds that had been identified to support the Ray-Ban effort ($1.2M) were re-budgeted for other LEP projects.

The inspection and measurement of the two hundred and forty (240) pair of LEP spectacles and 15 lens blanks previously received from Pilkington continued. Ten random samples of the WD1A IAS spectacles were measured to establish expected variability. Pilkington continued to make progress in producing the remaining deliverable samples under the WARDOVE Phase 3 contract. Five Navy LEP frames were received and will be used in an attempt to demonstrate the capability of the local optical shop to trim existing LEP lenses and to fit them in the Navy frames. This completes the hardware deliverables under the Phase 3 WARDOVE contract.

Physical evaluation of the rugate filter LEP lenses and the five pair of spectacles provided by Rockwell continued but was postponed to perform evaluations of the 8-diopter spectacles and inspection of the Phase 3 samples.

The electronics, hardware and machined parts for the two AMPS, one for Rockwell and one for AFRL/HEDO, were assembled and made operational. One of the units was incorporated in the PEATS setup and is being used to manually position samples under software control.

The evaluations of the spectral measuring capabilities of the Protective Eyewear Automated Test System (PEATS) were discontinued. We were unable to calibrate the amplitude of the signals from the different portions of the spectrum. We are proceeding with optical quality measurements that do not depend on quantitative data from the CCD camera. Power, prism and distortion measures depend on position data from the CCD array and do not require quantitative amplitude data from the camera. The optics for the Ronchi test for the distortion and power measurements were set-up and Labview software was written to collect the Ronchi fringe pattern data. The new AMPS was incorporated in the PEATS for holding the samples being tested. The software to process the fringe data to obtain power measurements was completed and initial tests were conducted.

Work continued to setup the LEVEL facility for off-axis exposures. The calibration of the laser irradiance sensor in the cockpit with the external sensor has been a problem. The in-cockpit sensor calibration factor must compensate not only for the offset in position but also for the various angles through the curved canopy. The reference sensor was repositioned from inside the canopy to the optical table, sampling the beam in a more reliable and stable fashion than was possible with the in-canopy arrangement. Optimization and cross calibration as a function of angle of incidence on the canopy was completed. A headrest was installed in the canopy to help insure consistent subject positioning. Two "pilot" subjects were run in LEVEL with the R20SA Rugate, the K9192 Holographic and the Q42SB DADS LEP through all off-axis angles (0 to 45 degrees in 5-degree increments). Data indicate no measurable effect of laser glare at greater than 10 degrees on HUD acuity at the current laser intensity. Consequently, no amelioration of effect by the LEP could be demonstrated. There were subjective effects noted (as before, preference for the dye based LEP). The R20SA Rugate, the K9192 Holographic and the Q42SB DADS LEP were measured with the laser densitometer in the "as worn position" in a pupillocentric geometry. The resulting curves were compared to the "eyepro" model outputs and to the psychophysical perimeter data previously gathered.

An Air Mobility Command TR covers the data collected on the C-130 E/H aircraft and the C-17 aircraft. An Air Force Special Operations Command TR covers the data collected on the AC-130U, the MC-130H and the MH-53M aircraft.

Continued support and assistance were provided for the development of the Risk Management Tool. The eye protection configurations examined include: night vision goggles without spectacles, the Improved Aircrew Spectacle (IAS) without side shields, the Improved Aircrew Spectacle (IAS) with side shields, and the Glendale Santa Cruz LEP frame. Data collection for subjects and the different eyewear configurations using the FOVEA is completed.

Under the Phase 4 WARDOVE contract, Pilkington will modify existing coating designs to produce dielectric reflective LEP for the ABL wavelengths and demonstrate the scripting of dielectric LEP. Initial design modifications for the ABL coatings were performed and delivered by Pilkington. Two LEP coatings were designed. One coating provides for protection from the three ABL wavelengths as a stand-alone coating. The second coating provides for protection at the 1315nm wavelength only. This second coating would be used in conjunction with the WD1A coating since the WD1A coating provides protection for the other two ABL wavelengths as well as other NIR wavelengths. The design calls for the 1315nm-only coating to be applied to the base lens and the WD1A coating to be applied to the cap lenses. The two lenses would then be laminated, thus providing ABL protection and NIR protection. The coating cannot be done as a single coating because of the thickness of the coatings. The actual implementation of these designs and deposition of the coatings remains to be demonstrated. The first coating runs for the ABL coatings are expected to be performed during the later part of August, depending on coating chamber availability. Coating chambers at Pilkington have been occupied by Block 0 CLEPIR spectacles. Pilkington has been performing initial trails of scripting LEP lenses. The early results of grinding and polishing the lenses after lamination were successful. The final lenses for the prescription trials cannot be produced until the 6-diopter mold, being fabricated by AOtec, is completed.

Gentex Corporation responded to our request to purchase 6 diopter lenses made from their A-195 NIR laser protection dye (after nearly one year of repeated requests). A purchase order was issued to Gentex for 40 pair of these lenses. The A-195 dye appears to provide the protection of the FV-9 with much greater luminous transmittance. Both the improved FV-9 formulation from Glendale and the A-195 from Gentex are candidates for use as side shield material for the CLEPIR spectacles.

Several different types of full coverage protective goggles were ordered and received from several vendors. The formats of these clear goggles are being examined and considered for LEP used by AFSOC and other AF ground forces. The Kroop goggles, provided to us by AFSOC, were examined and new goggles were acquired from Kroop. These "jockey goggles" are worn by many of the AFSOC personnel in different missions. The Kroop goggles have extremely poor optical quality and it is not yet known what features of the goggles appeal to the AFSOC personnel.

Six pair of WD1A spectacles were measured and the lenses removed from the gold IAS frames. The lenses were mounted in black IAS frames so that they would be like the Block 0 CLEPIR spectacles. These spectacles will be available if required for support of the USAFE safe-to-fly effort.

Investigations of available laser sources and detectors for use in measuring LEP at 1315nm continued. It is desired to incorporate a 1315nm source and detector in the laser densitometer for measuring the high optical densities of ABL LEP. No suitable lasers at 1315nm have been found. Purchase orders were submitted for two lasers that operate at 1319nm and 1313nm. Both of the laser wavelengths will be used for making measurements of ABL LEP. Purchase orders were also submitted for detectors and narrow band filters to be used with these lasers in the laser densitometer.

Data analysis for the Pilkington dye and dielectric spectacle (DADS) and the Rockwell R20SA rugate spectacle is on going. The evaluations of in-band LEP will continue with holographic spectacles.

An experimental plan for laboratory assessment of the performance effects of side shields has been developed. The proposal, entitled Peripheral Visual Capability and the Impact of Peripheral Luminance Reduction, includes an extensive literature review and qualitative methods for a dual task paradigm to evaluate the workload imposed by a series of different transmission side shields.

The formats of the clear goggles acquired commercially was examined and considered for LEP used by AFSOC and other AF ground forces. The Kroop goggles, provided by AFSOC, were examined and new goggles were acquired from Kroop. Discussions with individuals from AFSOC related to the use of the Kroop goggles continue. One pair of Kroop goggles was provided to Glendale for them to assess the possibility of producing FV-9 material that could be used in the goggles.

The data collection to assess the color vision effects of the WD4, Advanced Pointer Protection (APP), is continuing. Color matching data for two WD4 samples was collected and analyzed. A presentation for the LMB 2001 conference was prepared. Color naming in the CSI task was delayed pending the solution of computer problems.

The final version of a Fact Sheet describing the use and care of the CLEPIR spectacles was completed. Continued support and assistance were provided for the development of the Risk Management Tool. The eye protection configurations that were examined included night vision goggles without spectacles, the Improved Aircrew Spectacle (IAS) without side shields, the Improved Aircrew Spectacle (IAS) with side shields and the OFS wraparound frame. Data collection for subjects and the different eyewear configurations using the FOVEA was completed.

A number of commercial LEP materials used in the Ultra-short pulse laser bleaching studies were measured with the laser densitometer. Comparison of the results was performed. Further bleaching studies should include the measurement of the LEP at cw low power as a baseline to the higher intensity short pulse exposures.

Data analysis for the Thales dye and dielectric spectacle (DADS) and the Rockwell R20SA rugate spectacle is on-going. The DADS data are available to support the SPO acquisition and qualification of LEP devices. The evaluations of in-band LEP continued with holographic spectacles and rugate filters when samples are obtained. A plan for evaluations of holographic LEP spectacles was completed. A subcontract with Kaiser Optical Systems to acquire the holographic LEP for our comparative evaluations with rugate and dye technologies was completed. Kaiser produced holographic spectacles for NGIT and AFRL/HEDO.

The evaluation of the field of regard (FOR) and the field of view (FOV) in the FOVEA of LEP frames being considered by Kaiser Optical Systems for the SPO Aircrew Laser Eye Protection (ALEP) program was completed.

Data collection for subjects and the different eyewear configurations using the FOVEA was completed. The eye protection configurations that were examined included night vision goggles without spectacles, the Improved Aircrew Spectacle (IAS) without side shields, the Improved Aircrew Spectacle (IAS) with side shields and the OFS wraparound frame. A recheck of the FOVEA data was performed.

Under the Phase 4 WARDOVE contract, Thales will modify existing coating designs to produce dielectric reflective LEP for the ABL wavelengths and demonstrate the scripting of dielectric LEP. The 6 diopter base curve blanks from AOtec were delivered to Thales. Initial trial coatings for the two different ABL coatings were performed using lens blanks from COIL. Thales successfully produced lenses with the ABL only (three lines) coating on the COIL blanks and delivered a sample pair of spectacles. The transmittance of the lenses in these spectacles was measured and the protection at the ABL wavelengths was determined. Thales has been performing initial trails of scripting LEP lenses using blanks produced by COIL. Four laminated LEP lens blanks with the WD1A coating were obtained from Thales. These blanks were ground and polished to specified prescriptions and placed in IAS frames by the Optical Research Unit at Brooks AFB. The results of these trials indicated that dielectric coated LEP can be scripted using relatively standard methods for working polycarbonate. Since the Optical Research Unit does not have a hard coating capability, these lenses were hard-coated on the rear side by a local ophthalmic shop. The early results of grinding and polishing the lenses after lamination were successful. The final lenses for the ABL protection and the prescription trials were produced on the lens blanks made by AOtec. These blanks were produced and delivered to Thales in March. Initial runs of the WD1A and the ABL coatings on the AOtec blanks were performed. Difficulties with increased haze were encountered using the AOtec blanks. Some difficulties were encountered with delamination of the ABL coated AOtec lens blanks during the edging process. An initial pair of spectacles with ABL protection (using COIL lens blanks) was delivered and physical evaluations were performed. The protection levels were acceptable. Thus far the capability to place the ABL or the CS7-345 (WD1A) coatings on the convex side of a lens blank have not been successful. Prescriptions for 10 individuals were provided to Thales. Thales provided WD1A spectacles in these scripts and also provided 10 pair of blank WD1A lenses that could be scripted for performing the field studies. Early information from Thales indicated that they were experiencing difficulties in producing the high negative scripts. A quotation was requested for additional scriptable lenses. An additional 25 to 50 pair of scriptable lenses were purchased to support the laboratory and field evaluations of prescription LEP.

A comparison of a new Glendale dye that provides the same protection as the FV-9 with higher luminous transmittance was performed. The initial results indicate that the FV-9 and the A-195 dye samples are approximately equivalent when the requirement to provide 4 OD or greater from 800nm to 1100nm is applied. The new dye from Glendale does not meet this requirement. Glendale has absorptive dye LEP that provides protection out to 1400nm. We requested samples for consideration as ABL wavelength protection. We received two samples in the Millennia wraparound format and performed spectral and laser density measurements on these devices. This LEP is designed to provide protection for communications diodes and is a commercial product called Laser-Gard "Diode"

LVT25. The measurements indicated that these LEP provide a significant amount of protection for all the ABL wavelengths. The luminous transmittance of the LVT25 devices (approx. 30%) may be too low for night use but this dye is very promising for ABL protection.

The laser densitometer is now capable of measuring LEP for the ABL program. Laser sources and detectors were incorporated in the laser densitometer for measuring the high optical densities of ABL LEP at 1315nm. Since no suitable lasers operating at 1315nm were found, two lasers that operate at 1319nm and 1313nm were purchased and installed in the laser densitometer. Both of the laser wavelengths will be used for making measurements of ABL LEP. Alternative laser sources to a ruby laser to measure samples at 694nm were investigated. A tunable cw Ti:sapphire laser is the prime candidate.

The laboratory vision performance data for the DADS3 is available to support the SPO acquisition and qualification of LEP devices. Evaluations of in-band LEP with holographic and rugate filters continues. Holographic spectacles were delivered under the subcontract with Kaiser Optical Systems. Spectacles with the same holographic filter used by the Navy EDU-5/P are available in the LAS frame. A partial delivery of the LAS spectacles with the Air Force version of the holographic filter was received.

Evaluation of the field of regard (FOR) and the field of view (FOV) in the FOVEA of LEP frames being considered by Kaiser Optical Systems for the SPO Aircrew Laser Eye Protection (ALEP) program was completed.

Data collection for subjects and the different eyewear configurations using the FOVEA was completed. The eye protection configurations examined included night vision goggles without spectacles, the Improved Aircrew Spectacle (IAS) without side shields, the Improved Aircrew Spectacle (IAS) with side shields and the OFS wraparound frame. A recheck of the FOVEA data was performed. The report documenting the FOVEA study entitled Measurement of Coverage Provided by Laser Eye Protection Spectacle Prototypes was completed.

An experimental plan for laboratory assessment of the performance effects of side shields was developed, reviewed and revised. The proposal, entitled Peripheral Visual Capability and the Impact of Peripheral Luminance Reduction, includes an extensive literature review and qualitative methods for a dual task paradigm to evaluate the workload imposed by a series of different transmission side shields. The proposal was approved by the Human Use committee. Four test subjects trained on the central task and are being titrated on the peripheral tasks to tune the stimuli and measure their thresholds. Some data were collected on the peripheral tasks with calibrated neutral density and haze optical samples. This study was to determine the interaction of transmittance and haze. A poster presentation entitled "The Effects of Spectacle Sideshield Transmittance and Haze on Peripheral Detection in a Dual-Task Paradigm" was presented at the American Academy of Optometry (AAO) meeting this month. Efforts to prepare plans for the field assessment of side shields were begun but have been second priority to the scripted LEP planning. The methods for evaluation of the visual effects of wearing a visor in conjunction with the WD1A LEP were also considered.

A "quick look" ground cockpit assessment of LEP spectacles requested by the 311th HSW and HQ ACC was conducted in select aircraft. Ground cockpit assessments were accomplished in the following aircraft: F-16D, AC-130U, MC-130H, MH-53J/M, C-17A, and C-130H3. The quick look assessments were completed at Kelly AFB, Hurlburt Field and Charleston AFB. The day and night internal and external visual effects on aircrew wearing the laser eye protection spectacles were assessed using a questionnaire. A final report was prepared and modified to permit publication at the FOUO level.

Lens blanks with absorptive Green and Near Out of Band (GNOOB) protection received from AFRL/MLPJ were evaluated. Spectral measurements indicated that these samples have a relatively low luminous transmittance and are probably not acceptable for night use. The dyes used for this GNOOB filter were designed to provide the perception of neutrality. The dyes used in the GNOOB evidence strong phosphorescence when illuminated with green laser light. These GNOOB filters were compared to the Barnes dye filters developed in the late 1980s. GNOOB and Barnes filters were trimmed and mounted in LAS frames for evaluation.

Evidence from digital pictures and videotape tests conducted at Fallon NAS indicates that the optical return from reflective LEP must be considered. This is particularly important for potential ground force applications.

The LEVEL facility has been setup for off-axis exposures. The LEVEL exposure control was reconfigured to permit variable intensity exposures using counter rotating neutral density wedges to control the intensity of the exposure. The software to control the wedges was developed and implemented. The programming for the criterion acuity measurement of glare spot size was developed. Program revisions were completed and subject testing was started in LEVEL for the glare-spread experiment. Three volunteers as well as the PI were run and the data compiled. Further experiments in the LEVEL will depend on a review of the results of the work to date. Work in the LEVEL was put on hold to concentrate on the planning and protocol for the scripted LEP evaluations. The PRK project required use of the LEVEL in January/February 2002 to complete subject testing.

2.9. Protection against Optical Systems: 311th HSW/YA Support

Significant Activities

Discussed the status and approach in early 2002 for implementing the development of side shields for the Improved Aircrew Spectacle (IAS) frame and the development of a wraparound frame for LEP.

We were informed by Ray-Ban that their parent company, Luxottica, had decided not to pursue work related to laser eye protection. The capability to produce LEP at Ray-Ban was essentially disbanded. This caused reassessment of the program to develop a wraparound frame for LEP. The SOW for selecting and producing prototype wraparound frames for wide field of view protection was completed. Suppliers will have to consider teaming arrangements to provide the knowledge and capability in frame design, ophthalmic optical media, and LEP dielectric coatings required to conduct the wraparound LEP development.

The draft Product Specification for Phase 1 laser eye protection, prepared by HSW/YACL, was reviewed and comments were provided. A telephone conference with the user community (ACC and AMC), AFRL/HEDO, AFRL/MLPJ, SAF/AQ and HSW was attended and supported.

The subcontract effort to obtain side shields made from laser protective material for the Artcraft Aircrew Frame was performed by Dalloz Safety (now Glendale/GPT). The first rapid prototype (SLA) side shields that were delivered were evaluated in the FOVEA facility. The field of coverage of this first prototype was determined to be 88%. Areas where coverage was lacking were examined and a second crude side shield was fabricated by TASC to fill the coverage gaps. The second side shield was evaluated in the FOVEA and was found to have 95% coverage. This side shield was reviewed by AFRL/HEDO and was sent to Glendale for designing and producing a second SLA prototype.

Feedback and comments were received from AOtec and Pilkington Optronics on the SOW for selecting and producing prototype wraparound frames for wide field of view protection and optimizing the base curve of the lenses for dielectric coatings. Pilkington and AOtec are considering teaming to accomplish this effort.

The specifications for the CLEPIR spectacles were provided to HSW/YA and discussions were conducted with the engineering staff. A plan and cost estimate for performing environmental testing on the CLEPIR spectacles was prepared and submitted to HSW/YA. The plan called for pre- and post-environmental exposure testing by TASC using AFRL/HEDO laboratory facilities and subcontracting of the environmental exposures to a testing laboratory such as UDRI.

2.10. Optical Radiation Safety: ORS Activities

Scope: This effort provided research support in the area of safety for lasers and broadband optical sources. It included all efforts necessary to make a credible recommendation for the safe use of optical sources. The type of activities included field and/or laboratory measurement of optical sources, survey of military test ranges for safe use of optical sources, analysis of optical system parameters and comparison to established safety standards, recommendations for personnel protection devices and procedures.

Significant Activities

Since award of this Task Order, work continued on some system measurement reports that were drafted under the prior TASC contract (F33615-92-C-0017). Revisions and STINFO routing were completed under this contract for the following items:

- On-site range surveys of United States Air Force Europe (USAFE) ranges.
- # AF 97-140: Melrose Range, Cannon AFB, NM.
- # AF 97-089: Densitometer measurement of two filter samples.
- # AF 97-151: Holloman AFB evaluation of a Large Thermal Blast Simulator. This simulator is used to test materials/equipment against the thermal effects of a nuclear fireball.
- # AF 96-075: This CL summarizes the latest Lockheed-Martin measurements of the LANTIRN AN/AAQ-14 laser pod.

System Measurements (Activity by Consultation Database Tracking #)

AF 97-131: The hazard evaluation and measurement report for the Green Beam Designator (GBD-II).

AF 97-139: ACP-2A laser pointer.

AF 97-169: Characterization and Hazard Evaluation of the LIA on the AC-130U aircraft.

AF 97-132: Characterization and evaluation of the IZLID-II Laser Pointer and Illuminator. This laser is a 870nm, 1-W laser operated by 3-C cell batteries.

AF 97-137: Characterization and evaluation of the TGO/IR Laser Illuminator. This is a 3-W, 810 nm laser operated by a standard 24V lithium battery.

AF 97-169: Characterization and Hazard Evaluation of the LIA on the AC130U aircraft.

AF 97-137: Characterization and evaluation of the TGO/IR Laser Illuminator. This is a 3-W, 810 nm laser operated by a standard 24V lithium battery.

AF 97-226: Characterization of the Training Mode for the AC-130U:LTD/RF.

#AF 97-239: Defense Special Weapons Agency (DSWA) at Kirtland AFB, NM requested hazard evaluation of four laser range finders. These were nanosecond pulse, diode laser units which seemed to exceed the ANSI Class I safety guidelines.

#AF 97-252: Phillips Laboratory requested assistance in the hazard analysis of a diode laser array, satellite communication laser system.

AF 97-185: ACP-2A Skin Hazards.

AF 97-210: Broadband Hazard Analysis-C-130 Infrared Landing Lights. Based upon information provided by Lockheed-Martin, a hazard analysis was accomplished.

AF 98-059: AC-130U:LTD/RF Training Mode hazard footprints. In addition to the AC-130U:LTD/RF laser characterization/hazard analysis, an updated hazard footprint summary was requested by the AC-130U:LTD/RF SPO.

AF 98-054: CL to give guidance to test/training range personnel. This simple guide discusses the various issues involved with purchasing LEP for ground personnel.

#AF 98-099: A calculation of the hazard exposure time at fixed altitude was accomplished for HQ PACAF/DOT to assist in the development of CONOPS for the ACP-2A.

AF 98-071: Characterization report and safety analysis for the prototype Human Intruder Detection System (HID). This laser is being developed under a SBIR at Hanscom AFB. #AF 98-095: A brief summary of the hazards associated with visible laser pointers was prepared from FAQs and recent presentations on the subject.

AF 98-113: An evaluation of potential hazards from a UV illuminator/beacon system.

#AF 98-195: WR ALC/LUG, Warner-Robins AFB requested an update to the hazard analysis for the AN/AAT-3 laser illuminator on the AC-130H aircraft.

#AF 98-171: AFRL/HECV, Wright-Patterson AFB, OH requested hazard evaluation information for the Visual Retinal Display (VRD) laser. The system scans a laser directly on the retina to project an image over 30 degrees field of view.

#AF 98-112: FDA Exemption Process. A letter was recently drafted for the ABL SPO, Kirtland AFB, NM describing the process by which a laser system for DOD purchase may be exempted from the requirements of the 21CFR1040

(FDA Standard for Laser Manufacture). The document has been re-cast in a more general format to address generic questions about the process, rather than being ABL specific.

#AF 98-198 - #AF98-200: The GCP-1H "HEAVY" and GCP-1D "Destroyer" along with the IR "LaserGrip" Lasers were received for hazard characterization and evaluation.

#AF 1998-105: A hazard characterization measurement was conducted at Hurlburt Field FL for the AN/ALQ-144 IR countermeasure system during the week of 03 August 1998. This measurement was completed to address an alleged exposure to the AN/ALQ-144 system by Hurlburt Field personnel.

#AF 1999-043: Ft. Drum Range, NYANG requested a hazard evaluation of the MANTIS (Multi-Adaptable Night Tactical Imaging System).

#AF 1999-097: 171ST MSG/SGPB requested information on the LaserGrips Visible Laser handgun aiming device. The laser is similar to the LaserGrips IR evaluated recently.

IR Laser Illuminator Review. This report summarizes recently deployed IR illuminator and pointer hazards. It effectively summarizes the characteristics of several systems to provide a response to frequently asked questions of the Optical Radiation Safety Team.

Range Survey Activity

- Range Survey Reports for the USAFE Malacky range in Slovakia (AL/OE-CL-1997-0177, 18 Sep 1997), and an update to the Smoky Hill range at McConnell AFB, Kansas (AL/OE-CL-1997-0174, 11 Sep 1997).
- On-site range surveys of Pacific United States Air Force (PACAF) ranges were completed 8 - 24 September 1997. PACAF ranges surveyed included: Pil Sung Range, Koon Ni Range, and the Rodriguez Range Complex. These ranges are used by Osan and Kunsan Air Bases in Korea for training operations.
- The range survey reports for the Tunisia (Ben Ghilouf) USAFE ranges were completed. The reports were finalized on 29 January 1998.
- The range survey report for the Falcon Range, AFRES, Ft. Sill, OK, was finalized on 8 January 1998.
- Range survey reports for the Kansas Air National Guard - Smoky Hill Range, Salina, KS, conducted 17-19 February 1998, were quite extensive due to the addition of aircraft flight profiles and several new ground-based laser designation sites.
- The report for the Konya Range, Turkey, was prepared according to the format specified by USAFE.
- The optical radiation safety survey for the Razorback Range, Ft. Smith, AK (ANG) was conducted.
- The on-site survey of Grand Bay Range, Moody AFB, GA was accomplished 6-9 July 1998
- The on-site survey of Avon Park Range FL, (Det 1, 347th Ops Group, Moody AFB GA), was conducted 5-7 August 1998
- The on-site survey of Poinsett Range was conducted during 15-18 September 1998.
- 277 OSS, Melrose Range, NM has requested an updated AN/ASQ-170 TADS laser hazard footprint as an addendum to his range survey.

- Conducted the on-site survey of the Holloman AFB Ranges: Oscura Range, Red Rio Range and McGregor Range during the week of 17 May 1999. The Hardwood Range on-site survey was conducted 24-26 May 1999.
- Conducted the on-site survey of the Saylor Creek Range, ID during the week of 16 August.
- Conducted the on-site survey of Grayling Range, MI during the week of 30 August.
- Conducted the on-site surveys of the Atterbury, IN and Jefferson Proving Ground, IN ranges during the week of 26 July 1999.
- Conducted the on-site survey of the Nellis AFB Range complex during the week of 20 September 1999. Eight (8) separate reports summarizing the survey results from the various Nellis ranges were distributed.
- The on-site survey of Ft. Drum Range, an ANG Range in New York, was conducted during the week of 10 May.
- The on-site survey of the ANG McMullen Range, TX was conducted in May.
- Laser footprint computations for the use of the LITENING II Pod on Bollen Range, Ft. Indiantown Gap, PA were requested.
- TASC and AFIERA personnel conducted the on-site survey of Utah Test and Training Range (UTTR) during the week of September 18, 2000.
- Conducted the on-site survey of Centennial Range, NM 17-19 January.
- The on-site survey of the Goldwater Range Complex (Luke AFB AZ) was completed during 19-23 March. Three separate ranges were evaluated with Northrop Grumman and AFRL personnel drafting concurrent reports. Also, LRMS was successfully installed at this location with on-site training being provided.
- The on-site surveys of the Kuchyna Range (Slovakia) and Polygone Range (Germany) were completed during 26 March – 6 April.
- The on-site survey of the Juniper Butte Range (Mt. Home AFB ID) was completed 21 – 24 May.
- The on-site survey of the Smoky Hill Ranges (KS ANG) was completed during 4-8 June. The CAT II LSO course was provided. Also, LRMS was successfully installed at this location with on-site training being provided. Six separate tactical Ranges were evaluated.
- The on-site survey of the Razorback Range (AR ANG) was completed during 16-18 July. The CAT II LSO course was also provided. LRMS was successfully installed at this location with on-site training being provided.
- The on-site survey of the Grand Bay Range (Moody AFB GA) was completed during 27-31 August. Also, LRMS was successfully installed at this location with on-site training being provided.
- The on-site survey of the Townsend Range (GA ANG) was completed 27-31 August. LRMS was installed with on-site training being provided.
- The on-site survey of the Poinsett Range (Shaw AFB SC) was completed during 24-26 September.
- The on-site survey of the Falcon Range (Ft. Sill OK) was completed 24-26 October. LRMS was successfully installed with on-site training provided.
- The on-site survey of the Avon Park Range (MacDill AFB FL) was completed 25-29 September. LRMS was successfully installed with on-site training provided.

- The on-site survey of the Hardwood Range (Volk Field CRTC, WIANG) was completed 28 February. LRMS was successfully installed with on-site training provided.
- The 149 FW/DET1 (TXANG) requested that AFRL/HEDO evaluate the McMullen Range's Yankee target site for rotary-wing based laser operations.
- The on-site surveys of the Oscura and Red Rio Ranges (Holloman AFB NM) were completed 7 May. LRMS was successfully installed at this location with on-site training being provided.
- The on-site survey of the Melrose Range (Cannon AFB NM) was completed 21 May. LRMS was successfully installed at this location with on-site training being provided. CAT IIR LSO training was also provided.
- The on-site survey of the Dare County Range (Seymour Johnson AFB SC) was completed 11 June. LRMS was successfully installed at this location with on-site training being provided.
- The on-site survey of the Saylor Creek Range (Mountain Home AFB ID) was completed 24 June. LRMS was successfully installed at this location with on-site training being provided.
- The on-site survey of the Jefferson Proving Ground Range (IN ANG) was completed 7 August. LRMS was successfully installed at this location with on-site training being provided. CAT IIR LSO training was also provided.
- The on-site survey of the Camp Atterbury Range (IN ANG) was completed 8 August. LRMS was successfully installed at this location with on-site training being provided. CAT IIR LSO training was also provided.
- The on-site survey of the Grayling Range (Alpena, MI CRTC) was completed 20 August. LRMS was successfully installed at this location with on-site training being provided.
- The on-site survey of the Nellis Test and Training Range (NTTR) complex was completed during the week of 9 September. LRMS was successfully installed at this location with on-site training being provided. CAT IIR LSO training was also provided.
- The onsite survey of the Konya Range, Turkey was completed during the week of 11 November. LRMS was successfully installed and CAT II LSO Training was provided at several USAFE locations.

Figure 1 illustrates the number of consultations completed during the past 13 months. Also indicated is the number of responses by type, such as by telephoning information, or by sending a formal Consultative Letter (CL) to the requester.

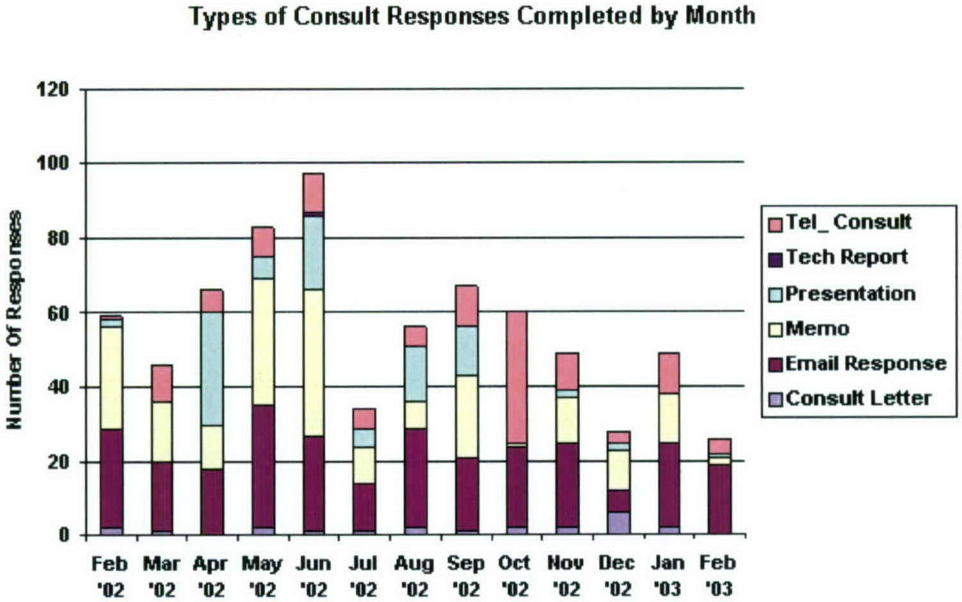

Figure 1. ORS Consult Response by Type and Month.

Figure 2 illustrates the number of consults completed per fiscal year since FY95. Note that a record number of consults were completed during FY02. A similar number is expected during FY03.

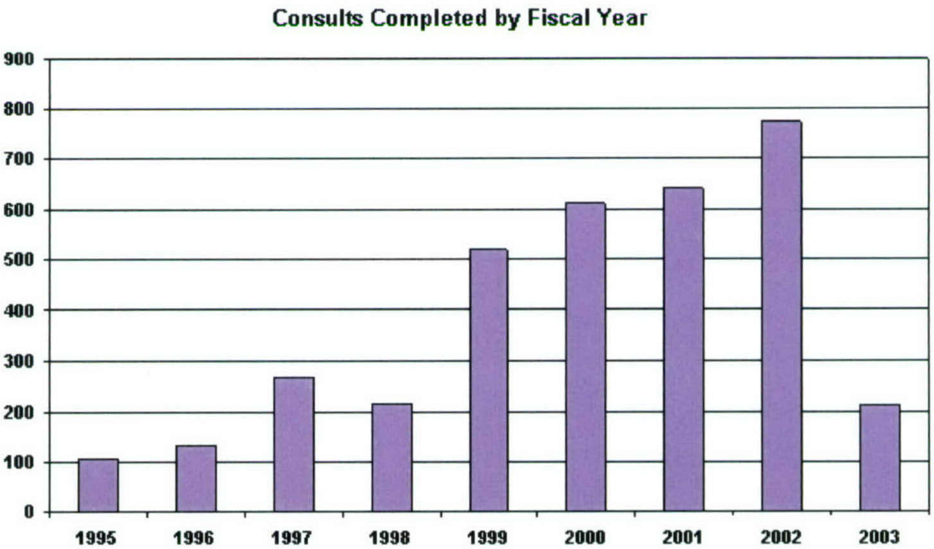

Figure 2. ORS Consults by Fiscal Year.

2.11. Program Management and Sustainment: Program Management

Scope: This effort provided research support tasks for the administration and management of the on-site contract and task orders, system administration of computer assets, and calibration of test equipment.

Significant Activities

The major activities during July 1997 were the establishment of an overall work breakdown structure (WBS) in accordance with the original proposal TASC submitted for the T.O., the development of budgets for the major technical areas, and the opening of appropriate job numbers to collect costs. MS Excel spreadsheets were developed and populated for both T.O. 1 and T.O. 2 to facilitate the required project budget reporting and tracking on the contract. MS Project schedule files were also developed.

A lot of preliminary planning was conducted to define alternative methods to present data on the IPTs in a manner such that it was easily assessable to, and useable by, all members of an IPT. Research was conducted specifically into the MS Office 97 suite to define how the applications it contains, such as Exchange and Outlook, can be used to facilitate data flow and data management. Team Manager, also an MS product, is also under consideration as a tool to implement the IPT process since it is fully integrated with all Office 97 applications and with MS Project, which will be used to document project schedules.

Task order number #007 for "Biomedical Effects and Treatment of Laser Injuries" research support to the United States Army Medical Research Detachment (USAMRD) at Brooks AFB was awarded in December 1998, and appropriate job numbers were established to support the effort. Project charge accounts were configured to accommodate the Entrepreneurial Research "Strobing Laser Effects on Pilot Performance." This project will be executed under Task Order 4 or the Personnel Susceptibility IPT. A Task Order to Veridian, Inc. (formerly SRL, Inc.), a TASC Team-member on the OR&FS Contract, for support to the ER project commenced during the reporting period.

Secured approval to proceed with the Laser Transient Effects study under Task Order #0004. Definitive plans were discussed with the Air Force regarding staffing, configuration of the laboratory, protocol development and data collection.

Efforts continue toward a restart of LTAS development. A number of discussions and planning sessions took place and a specific plan emerged that included several developmental items and collaboration with the Navy to integrate some LTAS elements with LTAMPS.

The situation with the Computer System Administration function on the OR&FS contract stabilized. Centralized computer system administration (in its present form) could not meet the needs of HEDO. It was determined that something close to full time support, on-the-scene and directly available, would be needed to ensure peak efficiency in the research lines that depend on computer support.

A new Task Order replaced the Task Order for Sustainment Services (T.O. #10) that expired in August 2000. The question regarding the computer system administration function on the OR&FS contract was settled, and the new Task Order reflected this. All basic network administration support was removed from the follow-on Task Order and became the responsibility of a centralized computer system administration agency on base.

During the reporting period, end-of-year funds were added to this contract and placed on Task Orders 4, 11, 14, 15 and 18 to ensure continuation of critical work under these Task Orders.

Final action was completed during January 2001 on the HEDO request to amend the DD-254 on this contract (F41624-97-D-9000) so that access to SCI material (by appropriately cleared individuals) could take place.

Data collection was completed on the multiple pulse intervisibility study, and the results were analyzed. TASC completed the majority of the work on the new LHAZ version 4.0. The HEL Safety Team released the Beta version of the Laser Range Safety Tool (LRST) and conducted orientations at Vandenburg and White Sands.

During May, the Program Manager continued working with personnel from USAFSAM on a potential modification to Task Order #15 for PRK support. This modification would extend the performance period and add labor to support a new PRK research effort involving aircrew and special duty personnel.

Team members assisted in the development of numerous ideas for initiatives for homeland defense as part of Project NOBLE EAGLE. This included development of documentation and preliminary execution plans for these projects. In addition, during September 2001, the Program Manager participated in the activities of most of the research IPTs and planned for the smooth and efficient use of personnel and hardware resources among the several Task Orders.

The program manager participated in a top-level AFRL/HEDO management review of the Task Order #4 vision science research projects on 13 September 2002. To facilitate this review, presentations for each of the four task areas and an introductory briefing were prepared and briefed at the review. The presentations included details on the project background, customers, funding, technical approach, facilities and resources, plans and products, and future trends. The program manager also participated in an initial meeting to discuss sensitivity issues related to on-going Non-Lethal Technology projects.

The Northrop Grumman management team continued to provide extensive support to the Laser Eye Protection (LEP) team in the further preparation and justification of a strategic plan and budget for a long-term AFRL/HEDO LEP program.

All work covered by this task order transferred in late March to Management Task Order #003 on the new Optical Radiation and Field Services (OR&FS) contract, with the exception of the Work Unit Information System Support provided to the HED directorate office.

Northrop Grumman provided administrative support, oversight of the Human Work Unit Information System (HWIS) maintenance and updates, Research and Development (R&D) Case File administrative maintenance, preparation of financial reports for tracking and management of funds, and review of statements of work to identify and prepare appropriate Contract Data Requirements List (CDRL).

2.12. Program Management and Sustainment: Technical Processing and Sustainment Support

Significant Activities
This effort was successfully transitioned from the prior contract to this vehicle immediately upon award of the T.O. The TASC technical leads for this tasking coordinated an update to the FY97 Calibration Database listing to ensure all equipment requiring periodic calibration and/or maintenance was accounted for in the database. The major activities in September 1997 were the setup and installation of 14 PCs and four laptop computers to support the personnel protection IPT (Task Order #006), and developing a list of work items to be included in a Computer Systems Administration project plan under this 12-month task order. After missing two calibration cycles (April and July), Task Order #10 was awarded in August 1998 and periodic maintenance and calibration resumed.

The computer system administration function continued to be accomplished as a part-time assignment. TASC provided other resources, including consultants as necessary, to ensure this function is covered as required by the contract. TASC requested clarification from the Government as to the status of the System Administration function within this contract as we would prefer to obtain an additional system administration resource. This resource would add another dimension of computer engineering flexibility to this contract.

Majority of time during September 2000 was spent in preparation for the change over to base network administration support. Some final coordination took place in order to complete the hand over of all computer system administration support activities to a central agency. Planning was accomplished to define specific tasks in support of all HEDO specialized software and technical computing requirements.

During January 2001 TASC identified and obtained price quotes for replacement of servers and PCs/software packages. Updating of the database for equipment and software tracking is an ongoing process. Items added to the ADPE were marked with the appropriate barcode labels.

During July 2002, Northrop Grumman identified equipment due for annual calibration this quarter. Northrop Grumman coordinated with the Air Force equipment manager on items listed as being maintained/calibrated by the Air Force to ensure that required items are repaired as needed.

2.13. Associated Research Projects: ASBREM Support

Scope: The purpose of this contractual effort was to provide technical planning to support the optical radiation program. It covered support to the Air Force Research Laboratory-Armstrong Site Project Reliance Office for the Armed Services Biomedical Research Evaluation Management (ASBREM) Committee. Support involved addressing issues specific to the laser bioeffects program, as well as other related technologies.

Significant Activities

On July 1, TASC supported a meeting in McLean, VA of the provisional Needs Integration Subcommittee (NIS) of the ASBREM. The meeting was focused on how the committee would coordinate and, where appropriate, integrate service requirements into the biomedical Research Development and Acquisition (RD&A) arena. On July 2, TASC representatives supported a meeting of the ASEC held in Frederick, MD. The primary purpose was to discuss issues from the Biomedical Technology Area Review and Assessment (TARA), and the revision of the ASBREM. Dr. Polhamus supported the full ASBREM committee meeting held in the Pentagon on July 6. The meeting focused on the Biomedical TARA issues, the new charter, and the results of the July 1 meeting of the NIS. In preparation for all these meetings, read-ahead packages were prepared by TASC for senior Air Force Research Laboratory (AFRL) and Human Systems Center (HSC) leadership. As follow-on to these activities, TASC provided comments on the charter for the NIS, as well as on the revised ASBREM charter. TASC also provided a draft synopsis/trip report of the early July meetings and support to meetings with HSC senior leadership.

Activities in February and March 1999 focused on AF preparations for the Annual Biomedical Technology Area Review and Assessment (TARA). This included development of read-ahead material for the 311th HSW/CC and AFRL/HE as the principal attendees at the TARA, as well as accompanying the principals to the week-long TARA meetings held in Easton, MD. Support also involved assisting the staffing of the action items issued to the AF at the TARA, as well as working with the other services to provide a coordinated response to the action items. This included several General Officer-level teleconferences and no-notice meetings in support of AFRL/HE and the 311th HSW/CC. Additional support in this area included providing material to assist the decision process leading to the AF acceptance of the Chairmanship of the Defense Technology Area Plan (DTAP) for the Biomedical Panel, effective 1 June 1999.

The DTAP chairman asked our assistance in facilitating AF participation in pursuing funding from a FY 1999 congressional plus-up of $19.5M for "medical RDT&E." TASC briefed the 311th HSW Technical Integration Virtual Office (TIVO) on the opportunity, helped the TIVO structure a plan to develop proposals for the funding, and assisted HSW in building one of the proposals. Finally, TASC supported a trip to visit several AF/SG offices on Bolling AFB, as well as several congressional staffers on Capitol Hill on 29-30 March 1999.

During October 1999, our primary activity was support for the ASBREM meeting held in Washington, DC on 28 October. This involved preparation of read-ahead materials, pre-briefings, accompaniment of the chairman to DC for the meeting, and follow-up action items. Other activity involved further coordination with the Army and OSD on the "Wellness" DTO, as well as development of a staffing package to request funding from USAMRMC to support the requirement to chair the Program Review Panel for the FY99 Medical RDT&E $19.5M program.

TASC provided support for several key activities in February 2000. Early in the month a number of meetings were held to prepare for an AF-hosted VTC to review the status of all FY99 TARA Action Items, Findings and Recommendations. TASC also continued planning and preparation activities for the ASBREM Program Review to be held in March. This included establishment of the agenda, development of briefing format, contact with all planned briefers, arrangements with the Brooks Club, coordination with the Army and Navy units on Brooks AFB, reservations for VIP participants, verifying protocol requirements, and arranging audio-visual support.

TASC support during June was focused on preparations and execution of the 12 June Video Teleconference for the ASBREM Secretariat members. Other actions included preparations for the 11 July ASBREM meeting to be held in Washington, DC, especially read-aheads and preparatory material for the 311th Human Systems Wing Commander. Preparation also addressed the Defense Science and Technology Advisory Group "kickoff meeting" for this year's cycle of activities (also 11 July in DC).

ASBREM support continued to be focused on AF Technology Area Review and Assessment (TARA) preparation activities. TASC worked with DDR&E on defining the total scope of the agenda for the TARA and drafting the initial schedule.

Continued preparation for support to the FY02 DTAP cycle comprised a significant portion of the work during July 2001. However, support for an unplanned opportunity for the Air Force to actively participate in the Army's Biomedical STO/STEP execution planning process and Unfunded Requirement identification and prioritization was incorporated into the work plan. While AF participation did occur, the general consensus was that it should be much more timely and effective next year.

The addition of $25K to the contract should allow full support for ASEC activities through, the end of calendar year 2001.

During December, Northrop Grumman support consisted primarily of responding to multiple OSD, Army, and AF requests for information or input on varied organizational and program concerns. In addition, we provided an initial orientation on the AF participation in the ASBREM to the newly appointed AF co-chairman of the ASBREM JTCG-5.

During June 2002, Northrop Grumman continued its support to the AF ASEC in evaluating the nature of potential AF casualties resulting from an Information Warfare (IW) attack on our forces and the potential impact they might have on the AF/SG's Title X responsibilities into the 21st century. In this effort a classified interview was conducted of AF/SG personnel assigned to the AF Psychological Operations Office at the AF Air Intelligence Agency. Northrop Grumman also responded to several ASEC and Joint Technology Coordinating Group (JTCG)-initiated taskings throughout the month.

Northrop Grumman continued efforts to initiate and coordinate AF input to the forthcoming Biomedical Technology Area Review and Assessment (TARA) Review scheduled for early March 2003. Some specific efforts are as follows:

- Updated JTCG distribution list for AF personnel and their support teams assigned to contribute to the Biomedical TARA Review
- Distributed TARA guidance to AF JTCG POCs and their support teams, including the web site for the Defense S&T Planning Documentation Manual and QDR goals
- Requested and obtained preliminary guidance from AFRL/HEOX regarding AFRL and AFRL/HE coordination requirements for TARA
- Reviewed the draft Biomedical DTAP, making important suggestions and additions that highlighted USAF contributions and perspectives; ensured that AF comments were received on time and distributed to all Services POCs
- Ensured that Biomedical DTOs closely linked with the Human Systems DTOs were properly coordinated between the two Panels

Northrop Grumman continued efforts to support USAF participation in ASBREM and Project Reliance. Some specific efforts are as follows:

- Efforts initiated to update the new 311th HSW/CC on ASBREM, Project Reliance and TARA: History of ASBREM and Project Reliance; near-term management issues; Biomedical TARA findings, stakeholders, and charters; and AF comments on charter revisions.
- Initiated plans to visit Washington, DC and Ft Detrick, MD: Coordinated itinerary and agenda with DDR&E, AFRL/DC, USAMRIID, and USAMRMC; and prepared talking papers.

2.14. Associated Research Projects: Bio-Warfare Counterproliferation Research

Scope: The initial project under this task order supports the Counter Proliferation effort of HEDB. Using a Physiological Genetic approach, this project addresses Basic and Applied Research into the cell and molecular Physiology of actual and potential Biological Agents.

Significant Activities

June was the start-up month for this project, and initial efforts focused on the continued characterization of the lytic phase of Cherry Gamma Phage and isolation and purification of its DNA in preparation for the sequencing of its genome. During September 2002 Northrop Grumman continued the Cherry Gamma Phage studies, specifically focusing on the effect of various environmental conditions on phage life cycle during late stationary phase when spore formation begins to occur.

Northrop Grumman continued work in preparation for the Midway Fuchsia/CRASHPAD test series. This included participating in the Test Plan Working Group (TPWG) meeting held at DTRA in Albuquerque. In addition, we began our initial efforts on developing a new Bio-Agent Defeat concept for the PAD program. Northrop Grumman continued its support to the CRASHPAD bio-agent counter-force program, focusing on the initial planning for the upcoming Midway Fuchsia (MF) test series and the integration of the PAD and CRASHPAD Bioassay protocols. Work also began on making a DNA library for the CP51 bacteriophage in preparation for DNA sequencing.

The main focus of Northrop Grumman in this effort is support of HEDB's involvement in the DTRA Crashpad ACTD. This included participation in the planning, execution (both at the test range and in the laboratory) and functioning as the quality control focal point of the Bioassay component of the initial Midway Fuchsia full-scale test. Progress was made on the Concept Exploration front as well. In this regard, enough DNA from the CP51 phage of *Bacillus cereus* was isolated and purified to take the initial steps toward generating a complete genomic library for the organism in preparation for its sequencing. This work, done in conjunction with the Cherry Gamma Phage project, is aimed at obtaining a more complete and fundamental understanding of the *in vivo* interactions between Bacillus and its naturally occurring vial pathogens. In February 2003 we supported HEDB's involvement in the MF-2 and MF-3 tests at White Sands. This included writing data reports, responding to OSD level queries, developing the initial draft of the HEDB briefing at the MF-2 data review, participation in the data review itself, and participation in the actual MF-3 test at White Sands.

During April 2003, the Northrop Grumman team supported HEDB CrashPAD participation by attending both the Midway Fuchsia 3 Data Review and the final CrashPAD Program Management review. The team's performance throughout the project received high praise from both the DTRA and Air Force program managers. At the research bench, work continues on the CP51 phage project and we were able to renew our efforts on understanding the genetic makeup of the Alls-Gifford strain of Anthrax.

2.15. Associated Research Projects: PRK Support

Scope: The objective of this effort was to acquire clinical and research support for the Ophthalmology Branch, Aeromedical Consultation Service (ACS), USAFSAM, 311 Human Systems Wing programs to support the Aviation and Special Duty Personnel Photorefractive Keratectomy (PRK) and Surveillance Program and other Branch activities.

Significant Activities

This task order provided research support for the USAF Photorefractive Keratectomy (PRK) Study being performed by the Ophthalmology Branch, Aeromedical Consult Services (ACS), USAF School of Aerospace Medicine. Although the PRK study was already ongoing, this support project began in October 1998 and was scheduled to continue through July 2001.

Background. Photorefractive Keratectomy (PRK) is a relatively new advanced refractive surgical technique that uses an eximer laser to effectively and accurately treat myopia or nearsightedness and astigmatism, thus reducing dependence on spectacles or contact lenses. The aeromedical and military implications of this new technology are immense. With CSAF and USAF/SG support, Wilford Hall Medical Center, Department of Ophthalmology and SAM/ACS developed a collaborative USAF PRK Study to investigate the clinical course and duty impact of PRK on myopic, active duty, non-flying USAF personnel. Further, ACS established a refractive surgery center to assess visual performance of these PRK subjects.

Personnel. TASC and subcontractor Conceptual Mindworks, Incorporated (CMI) provided three full-time contract personnel to work on-site at the Ophthalmology

Branch to accomplish administrative and database support, ophthalmic support, and project leadership.

Technical Effort. To support the AF objectives of determining the applications and limitations of PRK in aerospace environments and building a foundation of policy decisions regarding the use of refractive surgery in the USAF, the project recruited a population of ~110 myopic, active duty USAF personnel (non-flying status) to participate in the PRK study. The subject population was divided into five groups: the PRK group (received corrective PRK surgery only); altitude, centrifuge and simulator groups (received PRK surgery and participated in altitude chamber, centrifuge and cockpit simulator training exercises both before and after the PRK); and the control group (no PRK but monitored over the same time frame as the other groups).

1. PRK group – All subjects have completed the PRK surgery in both eyes and are being monitored, postoperatively. The project plan called for vision testing at 1, 4, 6, 12 and 24 months post-op. (The other subject groups were to follow the same schedule for vision testing). Seventeen of the subjects have already completed the scheduled post-op exams through the 24-month follow-up. The remaining three PRK subjects are scheduled to complete the 24-month follow-ups in July.
2. Control group – The 20 subjects are receiving the same 24-month vision testing sequence. Upon completion of the testing sequence, control subjects may receive the PRK surgery if still eligible. Thirteen of the subjects have completed the 24-month testing and are done with the study. The remaining seven control subjects will have completed their 24-month follow-ups by December 2001.
3. Altitude group – The 20 subjects have all completed the pre-PRK altitude chamber exercises, have received the PRK surgery in both eyes, and are following the post-op testing and exercise schedule. All of the subjects have completed the 12-month follow-up testing and altitude chamber rides. Fourteen of those have also completed the 24-month testing and are done with the study. The remaining six altitude chamber subjects are scheduled to complete the study by August 2001.
4. Centrifuge group – There are currently 19 subjects participating in the study, all of whom have had the PRK surgery in both eyes. Only two of these subjects have completed the 24-month follow-ups. The remaining 17 subjects who have already had the PRK surgery will continue with their programmed follow-ups for the next 18 months, assuming the contract period of performance is extended to allow this activity.
5. Simulator group – There are currently 18 subjects participating in the study, 16 of whom have completed the PRK surgery and post-op testing through the 1-year milestone. (As a note from earlier reports, it is reiterated that the simulator was not operational for extended periods during the study and there was no opportunity to complete the two-year testing sequence for this group within the original period of performance. The majority of the subjects would reach the two-year milestone during January-February 2002). Two of the original 20 subjects were disqualified from the study. There are no plans to replace those subjects.

In summary, excluding the 20 control group subjects, the remaining 77 subjects were accepted into the study with the agreement that they receive PRK surgery early in the study and participate in the two-year post-op testing and exercise period. The PRK surgery has been completed on 75 of those subjects and 25 (in addition to 13 of the control group subjects) have completed the two-year sequence of follow-ups and are through with the study. With the exception of a few members of the centrifuge and simulator groups (as noted above), the remaining subjects completed the two-year testing sequence by the end of the calendar year.

Task Order # 20 was awarded in August 2001. According to the Task Order #20 statement of work entitled "Aviation and Special Duty Personnel PRK Program Clinical and Research Support," the contractor provides clinical and research support for the Ophthalmology Branch, Aeromedical Consultation Service (ACS), USAFSAM, 311th Human Systems Wing. Contractor support encompasses the Aviators and Special Duty Personnel Photorefractive Keratectomy (PRK) and Surveillance Programs and other Branch activities.

To support the Aviators PRK program, Northrop Grumman assigned an initial staff consisting of an administrative technician and a data entry technician/analyst. Northrop Grumman anticipates adding a licensed Doctor of Optometry to the staff early in 2002, pending funding approval for this slot. Dr. Joseph Zuclich is the Project Manager and provides managerial oversight for the Task Order #20 effort as he has done for the past two years on the initial USAF PRK study (T.O.#15).

A total of 29 of the PRK surgeries have been performed at Wilford Hall (22 pilots and seven Boom Operators). All of their pre-surgical vision test results have been entered into the database maintained by the contractor personnel. The analogous records from patients handled at other war fighter laser centers are entered into the database as they are received from attending AF Optometrists/Ophthalmologists.

Through the first Quarter of FY03, the Aviation and Special Duty PRK Registry has thoroughly reviewed 546 applicants for permission to proceed to have PRK at any of the five USAF Laser Centers. Of those, 402 have been approved for PRK and 128 have been denied. The subjects can be classified according to the following categories: Pilots – 54; Boom Operators – 12; Navigators – 168; Flight Surgeons – 19; Flying Class III (FC III) personnel – 291. The total number of surgeries performed to date at the USAF Laser Centers on aviators referred from the PRK Registry at Brooks City-Base is 254, which can be subdivided by category: Pilots – 28; Boom Operators – 8; Navigators – 92; Flight Surgeons – 8; FC III – 120.

Developed plans and made arrangements for a comprehensive Tri-service PRK and Contrast Sensitivity Working Group meeting to be hosted at Brooks City-Base, 28-30 January 2003, and put together an attendees list of over 70 national and international experts.

- Assimilated into the team a new ophthalmology technician to provide support for several new testing modalities, and transitioned in a temporary employee to provide coverage for the NGIT administrative technician on maternity leave.
- Edited and updated the A/SD PRK guidance policy and application form. Submitted to the USAF Optometry website, a PRK application "helpful hints"

section to provide new information for Ophthalmologists/Optometrists and Flight Surgeons.

- Streamlined the process for submitting test results reports to ACS, thereby improving quality control.
- Completed rough draft for first part of the 3rd Edition to the Night Vision Manual for Aviators that includes the section on unaided night vision.

Additional support to the ACS included 12 patient visits for fitting Rigid Gas Permeable (RGP) contact lenses for keratoconus, Intra-ocular lens (IOL) follow–up care, cycloplegic refractions for MFS pilot candidates, aeromedical waivers for trained aircrew, and baseline laser hazard eye examinations.

There is a potential problem of not being able to continue uninterrupted contractual support to the customer if a new contract, which will require a different contractual vehicle from the one currently used, is not in place by 7 May 2003 when the current contract runs out. Also, we must meet the challenge of having several new testing instruments coming on line which will mandate that more tests be run on each PRK patient, and being able to provide timely support to collect and analyze this additional data.

2.16. Modeling and Simulation: Optical Radiation Safety - Laser Range Management System

Significant Activities

Work continued on a realistic display of the beam hazard cone intersection with the terrain, and two range maps were assembled for a demonstration during the March IPT Meeting. This software tool will allow range survey teams to generate footprint computations more rapidly. A demonstration of this software for the ANG/DOB was conducted during the week of LSSWG (22-26 March 1999) to obtain inputs from range personnel. The project was received well, with several suggestions for data compatibility with other USAF DIS programs.

TASC continued to prepare an initial version of the laser range footprint calculation software. Recent features added include: Laser system database retrieval, improved programmable aircraft flight paths, programmable annotations for targets and other entities, and a map tool to be used in registering bitmaps to DTED data. Work continued to develop documentation and terrain databases for the Laser Range Management Software (LRMS). There was a successful installation of the Laser Range Management Software (LRMS) at the Range Safety Office, Edwards AFB CA. Users were trained on software operation and were provided a CD containing the software, operator's manual, and MIL-HDBK-828A.

Laser Range Management Software (LRMS) was installed at the following ranges and users were trained on software operation and provided a CD containing the software, operator's manual, and MIL-HDBK-828A.

Bollen Range, PA and Warren Grove Range, NJ
Cannon Range, MO and Utah Test and Training Range (UTTR)
Grand Bay Range (Moody AFB, GA)
Townsend Range (GA ANG)
Poinsett Range (Shaw AFB, SC)

Avon Park Range (MacDill AFB, FL)
Hardwood Range (Volk Field CRTC, WIANG)
Oscura and Red Rio Ranges (Holloman AFB, NM)
Melrose Range (Cannon AFB, NM)
Dare County Range (Seymour Johnson AFB, SC)
Saylor Creek Range (Mountain Home AFB, ID)
LRMS software was also installed at the U.S. Navy's China Lake (CA) Range Management Office.

A meeting was held to discuss funding for the LRMS Phase III effort. A number of issues were discussed with respect to enhancements that would be made to LRMS and a list of requested changes with priority assignments was assembled. The Northrop Grumman team reviewed those requests and priorities and put together a schedule representing what could be done within the scope of Phase III. Work on the Integrated Terrain Editor was suggested, but will not be covered under the current project plan. Work also began on the LRMS Phase III changes.

During August, work continued on the LRMS Phase III changes. Work focused on the entity identifiers and functionality to move, edit, and size the fonts. The font work originally started by adding code to render Non-Uniform Rational B-Splines (NURBS) curves on screen and then modified the FontRenderer code to use NURBS curves and polygons to render scalable, rotatable text. An open source library (FreeType) was found that could be used to render fonts under Windows as well as Linux and work was begun to add this library to LRMS.

TASC completed the first successful target scatter predictions using the MatLab version of LRST (LRST/M). LRST/M results for the WSMR ground test scenario compared well with measured data. In addition, LRST/M results were used to estimate expected flight test scatter signals for late August ACT/ABL testing at WSMR. The results showed that the field test team should wait until higher power lasers are available prior to further attempts to collect flight test data. Substantial progress was made in understanding the RDA Logicon documentation on Bidirectional Reflectance Distribution Functions (BRDFs) and the corresponding physics in the LRST/M model. Our improved understanding will allow increased accuracy in BRDF inputs that will be crucial for future code validation efforts. TASC found that a FORTRAN program is required to convert OCEL data to LRST/M input file data.

For the LRST laboratory measurements, TASC met with RDA Logicon to continue to work on BRDF theory. TASC has uncovered details that may explain why experimental results have not matched theory. For example, there are two cosine correction terms in the power prediction formula that were not accounted for in our theoretical calculations. TASC continued to "tune" the Nd:YAG beam to improve it's quality. Tuning included things such as spatial filtering and collimating. This did not improve the correlation with theory (i.e. experimental results were up to 200% higher than theory predicted).

For the LRST laboratory measurements, TASC successfully performed a target scatter experiment showing reasonable agreement (20% difference) with radiometric theory. A key breakthrough in this effort was to use a polarizer over the detector to emulate the OCEL laboratory measurement set-up. In addition, our set-up was modified to minimize detector measurement of beam scatter from “other-than-target” sources, such as laboratory air particles, mirrors, etc.

The LRST Software validation effort focused on two fronts. First, TASC continued to work on the OCEL-to-Maxwell-Beard BRDF conversion. We reviewed the existing documentation from RDA Logicon regarding the process of generating Maxwell-Beard BRDFs suitable for use by the LRST code from the OCEL laboratory measurements. In addition, TASC searched the Internet for information pertaining to the measurement of BRDFs. There is a growing interest in the physical phenomena underlying light propagation and reflection among members of the computer graphics community. As a result, there are numerous references to the calculation and application of BRDFs. The Maxwell-Beard approach appears to be one of the very few empirically driven BRDF models. Second, using these results, TASC participated in the OCEL-to-Maxwell-Beard summit, where TASC explained the structure of the materials database file (matter.dat) to the group. The materials database contains eight parameters for each Maxwell-Beard material entry. The eight parameters are the hemispherical reflectivity (Rh), the complex indices of refraction (n,k), the Lambertian reflectance (Rx), the volumetric reflectance (Rhov), the shadow mask parameters (tau,omega) and tilt function (Xi).

TASC modified the DAQ Card LabView program to accommodate new requirements based on meetings with the THEL group. It was learned that TASC will only have access to the range for up to two hours prior to firing the THEL laser. The issue of how to remotely trigger the data collection software was discussed at length. The final product of that discussion was to write the program in such a fashion so that the user sets up the equipment, specifies a certain delay period, and a data collection time interval, then starts the program. The program will be on “timer” mode until the delay time is exceeded, at which time the program saves data at a rate of 100 Hz for up to four hours. The 100 Hz data collection rate decision was the result of another meeting with Air Force personnel under the topic of “BRDF as a function of time.” It was decided that significant material deformations would not occur within time intervals of 10 milliseconds.

For the LRST model predictions, TASC took on the responsibility of converting the raw Optical Component Evaluation Laboratory (OCEL) data to LRST useable parameters as related to the Maxwell-Beard theory of modeling beam scatter from targets. Various mathematical techniques were used to calculate the Tilt Function, Fresnel Reflectivity, Complex and Real Indices of Refraction. These parameters were used in the LRST model to successfully calculate predictions for the small scale HEL lab at Brooks AFB. Preliminary results of experiments vs LRST predictions vs hand calculations agreed to values from 2% to better than 25% for most values, with outliers as far off as 62% at grazing angles.

TASC received the liquid nitrogen-cooled 3.8 micron detectors. Since the detectors arrived without mounting hardware, TASC designed and constructed appropriate mounting hardware so that the detector can be easily mounted to a tripod or optics table. Also, the detectors came without pointing optics so TASC designed and constructed an optical and laser pointing system for the detectors. Tests were conducted on the new detectors to verify their accuracy and sensitivity.

On 8 February 2000, TASC successfully completed Laser Target Scatter Study (LTASCS) Mission 01 at Brooks AFB. A 100 mW Nd:YAG laser, an aluminum target, and a sensor system were set up in the afternoon on a remote runway near the southeast corner of the base. The primary test objectives were to safely collect scatter signals, evaluate three detector FOV options, and evaluate secondary (i.e., atmospheric) scatter sources. Two scatter signals for each FOV option were recorded with the detector 10m away from the target and 60 degrees from the target normal. The average signal level was 6.8 mW/sq cm versus an LRST prediction of 5.2 mW/sq cm. No atmospheric scatter was detected. Most likely this was due to a vertical polarizer that was placed on the detector.

TASC conducted a Low Power Chemical Laser (LPCL) test at the High Energy Laser System Test Facility (HELSTF) at White Sands Missile Range, NM. HELSTF scientists provided a laser beam for this experiment from a 100 Watt output Deuterium Fluoride laser. TASC personnel measured the first laser target scatter signals with the new EO Systems liquid nitrogen cooled detector systems. Scatter signals were collected from an inert rocket warhead, two Satellite Assessment Center (SatAC) target coupons (used for LRST Matter.dat parameter determination), and one of our HEL target samples. This test provided valuable information used during preparation for the MIRACL laser test the following week.

The LRST software validation effort continued, evaluating two releases of the program (March 1 and March 14) by RDA. These releases showed that LRST still suffers from a number of user interface problems, some causing fatal errors. These problems were reported to RDA during the weekly telecons with them and by email. Another concern regarding LRST development is that the updated, more efficient physics algorithms, scheduled to be completed in January, are still not in the program. RDA reports that when using the Borland Development Environment, they have problems obtaining the same efficiency in these new algorithms that were developed under Microsoft Visual C++.

HEDO/TASC received two more releases of the LRST program from RDA this past month. The second release, received April 24, contained the new physics "shaders" with the faster operating algorithms for calculating intensity distribution for the golden sphere. This version does do the calculations significantly faster than the previous versions, but TASC noted and reported to RDA that the intensity pattern displayed by the program on the ground showed serious anomalies and did not match the rays displayed by the program. At this time, only the cylinder and flat surface shaders have been implemented, limiting the potential targets which can be evaluated by the program. TASC also described about 10 additional program defects for this release, and reported them to HEDO and RDA. In phone discussions RDA has emphasized that they don't have time to test or evaluate the releases they make to us, and are depending on HEDO/TASC to report to them any defects in the program. This has certainly been true as the past three releases we have received could not even be made to run until we obtained additional missing files from RDA that were not originally included in the release. As the program matures and nears final delivery, we have decided that a more formal methodology for tracking defects needs to be implemented.

TASC has continued to make progress on adding the capability to use bitmap images, such as satellite imagery or navigation charts, as a texture overlay for both the 3D and plan view displays of the LRST. As a result of this work, TASC has identified the importance of developing a method of configuration management in conjunction with RDA. RDA has attempted to allow HEDO/TASC internet access to their CM system, but this has not been possible because of firewall restrictions. TASC has worked out a procedure of notifying RDA via email whenever we work on existing LRST files, and requesting RDA check them out in our name.

Anticipating that HEDO and TASC may soon be taking over development of the LRST program, TASC has begun to develop some design documentation for the program. We believe that we will need the understanding we gain in creating this documentation to effectively correct the defects and add the capabilities that will still be lacking in the program. TASC ordered a software tool called Class Explorer Pro that works with the Borland C++ Builder environment and provides excellent design information directly from the source code.

TASC has continued working on the image overlay capability for LRST. We have ordered complete NIMA Compact Image Base (CIB) data for the Vandenberg and White Sands areas. TASC has also investigated potential sources of vector-type feature data. We have identified NIMA's Vector Product Format (VMAP) data as the best solution for adding data such as roads, rivers, range and political boundaries to the display.

HEDO, in conjunction with the ABL SPO, has decided to take over development of the LRST program as soon as RDA has expended the remaining funds on their contract. It appears that this will occur in August, and TASC has continued preparations to support this development effort in house. Our highest priority in this transition effort is to quickly develop documentation of the program's design and architecture. To support this effort, we purchased two copies of a program called Class Explorer Pro, which works in harmony with the Borland C++ Builder development environment, and offers a number of "automated" capabilities that will assist in the writing of this documentation.

On 15 August 2000, TASC and Dr. Kennedy visited the Optical Measurement Facility (OMF) at Wright Patterson AFB, OH. During this visit, we delivered HEL lab target samples for target scatter measurements at 1.06 and 3.39 micron wavelengths. In addition, we delivered a reflexite target sample. OMF performed diffuse reflectance measurements on this sample and processed data during the visit. This data will be used in developing a BRDF model using LRSTM to support NoDyCE test predictions. OMF personnel provided a tour of the measurement facilities and explained state-of-the-art techniques for minimizing uncertainties in target scatter measurements. These techniques will be incorporated in an automated target measurement system for the next phase of HEL lab measurements.

The final RDA-Logicon installment of the Laser Range Safety Tool (LRST) was released to HEDO on 7 August. That date marked the beginning of HEDO/TASC responsibility for development of the program. TASC has continued an intensive effort to document the program's design and function. TASC also prepared a transition plan showing the effort/cost required and a schedule of releases of the program. This plan was briefed to the ABL SPO on 22 August and showed several options. TASC also prepared an installation of the LRST program as delivered by Logicon for the SPO, and installed it on a computer at the SPO. TASC then focused its software development efforts on preparing a new release of the LRST for the SPO scheduled for the end of September.

On 14 September 2000, TASC hosted an ABL White Sands Missile Range (WSMR) Test Hazards Analysis meeting at Brooks AFB. The purpose of this meeting was to review a laser safety hazard analysis process to be used on an interim basis until LRST is releasable for range hazards assessments. Specifically we reviewed ABL program plans for missile drop tests (MARTI) and WSMR flight tests against a target aircraft orbiting north of the ABL aircraft. AFRL/HEDO agreed with the concept used to determine direct beam hazard potential. However, further investigation and analysis is required to determine if diffuse target reflection hazard results are acceptable.

Background research on the use of PRA elsewhere by the USAF revealed a recent report by the Committee on Space Launch Range Safety entitled *"Streamlining space launch range safety."* This report represents a significant finding as it describes the quantitative risk management approach used to support space launches and includes numbers for the common risk criteria agreed by the Range Commanders Council. This is important as it can be used as a precedent to support the application of PRA to laser safety. In addition, the report indicates that the risk modeling approach uses population databases. These databases are required for PRA modeling. A customer briefing was prepared and delivered, and it was agreed that TASC would try to identify a POC for the population modeling to pursue this matter.

TASC prepared a new Installation CD of the LRST program, which was provided by AFRL/HEDO to the ABL SPO on October 23. This release included a professional installation program and a nominal help file. TASC did not meet its objective of providing the capability to analyze complex targets and WSMR scenarios and trajectories in this release, but continued work on these capabilities and expects to be able to provide them for a release to the SPO mid-November. Several complex targets are now functional in LRST including the Theater Ballistic Missile and the Artillery Rocket. It has been necessary to build these models from scratch using the Satellite Assessment Center Modeling Tool (SMT), as the models provided by Logicon could not be read successfully by either LRST or SMT.

Regarding the Probabilistic Risk Assessment (PRA) program, TASC supported the Window on Science visit of Mr Karl Schulmeister to AFRL AFRL/HEDO, to discuss approaches to the application of PRA methodologies to high-energy laser safety. Similar techniques for lower powered lasers, with particular emphasis on uncertainty distributions and laser-tissue interactions, have recently been developed for exposure to space-based lasers (LIDARs) for the European Space Agency by a European team led by Mr. Schulmeister. During the visit, Mr Schulmeister presented and discussed the application of PRA techniques in laser safety with AFRL/HEDO scientists and suggested areas for potential collaborative efforts for the future. The approach to ocular damage modelling, and parts of the population model as developed by the Austrian Research Centers Seibersdorf (ARCS), are directly applicable to the PRA model for airborne high-energy lasers under development by AFRL/HEDO. Scope for further collaboration in these areas was identified, and a joint paper is planned on PRA for airborne (high energy) and space-based (low energy) applications for publication in a peer-reviewed journal.

Regarding the BI-14 project, TASC analyzed scatter data from the third rocket target. TASC also resolved data input file error problems so the LRST BRDF extraction tool could read Optical Measurement Facility target reflectivity data files. Following data file entry, TASC analyzed the input data using iterative curve fitting displays in the extraction tool. This was the first time HEDO has used the extraction tool to generate target reflectivity input parameter files for the LRST program. Finally, TASC reviewed the Nautilus/THEL security classification guidance (SCG). This SCG provides long awaited guidance that will allow us to properly mark future classified reports and analysis results.

TASC successfully used the 3.39 micron OMF BRDF data to create a matter file for LRST predictions. The task included modifying the OMF files to mimic OCEL files so that the BRDF Edit Tool would read the input files. After appropriately modifying the files, TASC did a successful extraction of the 3.39 micron BRDF data as supplied by OMF.

On the BI-14 project, TASC attempted to use the BRDF extraction tool to obtain diffuse aluminum target reflectivity parameters using OMF 3.39 micron data. The extraction tool was designed to read OCEL data files. We requested similarly formatted data files from the OMF group. While the data visually appeared similar, there were subtle differences that were discover by trial and error. We are developing a data conversion program that will convert OMF data to precisely the same file format as the OMF data. In addition, we used the BRDF extraction tool viewer to screen materials in the LRST target reflectivity database and selected candidate materials that we can use in this analysis.

TASC conducted an analysis of laser eye protection Optical Density (OD) requirements for a target aircraft during planned Airborne Laser program flight tests. TASC developed a methodology to obtain OD using ABL SPO provided beam propagation software and LabHaz (developed by TASC). We have completed data analysis for the Surrogate High Energy Laser and will draft a Technical Memo documenting the results next month.

TASC successfully created a CVS (Concurrent Versions System) repository for the LRST code that will provide an extremely valuable safety net during the software development and maintenance cycle. CVS provides mechanism for reverting to previous versions of the program while at the same time supporting ongoing software development.

For the software development of the LRST, TASC completed the Beta release, including development of the previously mentioned draft User's Manual. Installation CDs were produced and training sessions held at both Vandenberg AFB on 30 January 2001, and at White Sands Missile Range (WSMR) on 1 February 2001. The training session at Vandenberg was conducted for a class of fourteen people. The training class at WSMR consisted of nine people. The course consisted of an intensive three-hour introduction to LRST followed by an extended hands-on period. During both portions of the training, the participants showed great interest in the program and its capabilities. TASC finished both training sessions with the impression that the students grasped the concepts in operating LRST-Beta, and that TASC would receive useful feedback in the form of bug-tracking and GUI recommendations.

The Matlab version of LRST has been used to produce a time-slice intensity laser profile on the ground for a typical HEL engagement, and work has begun on subjecting this profile to a subset of the PRA probability density functions (for atmospheric scintillation, population density, and ocular damage). Effort thus far has focused on atmospheric propagation and a typical scintillation model has been implemented. The addition of the other PDFs will be used to demonstrate the amelioration of hazard zones by probabilistic risk assessment techniques.

The draft report on the Non-cooperative Dynamic Compensation Experiment (NoDyCE) study is currently under final review by TASC prior to submission to the USAF. The report will combine the preparatory experiments and results with the full details of the NoDyCE study including all field data results and their comparison to LRST predictions.

TASC drafted and presented an LRST software development plan and schedule to AFRL/HEDO. In creating this plan we identified and prioritized the tasks required to produce the next major release of LRST. The task list includes all of the items from the Traceability Matrix (LRST – Software Requirements Specification – Phase I & II) as well as new requirements which arose during the LRST training sessions at WSMR and VAFB.

As for the planar and volumetric boundary observers, LRST will implement two types of planar observers (horizontal and vertical) and two types of volumetric boundary observers (range boundary and airspace). The database representation for all of these observer types has been defined. The internal representation of the vertical planar observer class has been defined and implementation is nearing completion.

The Probabilistic Risk Assessment (PRA) session, despite being the closing session, was well attended with over 50 people participating. The session included presentations from four nations (US, UK, Austria and Israel) and provoked a variety of interesting questions. None of the papers, or subsequent questions, were particularly controversial. It is worth noting that the application of PRA to Laser Safety appears to be gaining acceptance in the International Laser Safety forum.

With respect to international cooperation on the PRA program, a meeting was held with the UK at the ILSC, and the AFRL/HEDO draft technical proposal for an MOU was discussed. The US explained the proposal in detail, and the UK agreed in principle to the content. Both nations agreed to send the proposal through their International Collaboration offices for approval. TASC has assisted AFRL/HEDO in responding to some subsequent UK questions related to the proposal.

TASC modified a laser range hazard analysis software package (LabHaz) to allow determination of simultaneous laser exposure hazards. A new Lab View algorithm was created, de-bugged and tested in support of this effort. This updated version (4.3) of LabHaz allows analysis of simultaneous exposures from up to four separate lasers. The individual laser hazard analysis results can be viewed independently from the simultaneous exposure results. This upgrade will greatly facilitate future analysis for direct beam hazards from systems like the Airborne Laser that can simultaneously operate multiple laser systems.

The database editor now provides functionality for editing sources (which represent the ABL aircraft), targets, sites, and three types of observers (point, planar, group) as well as numerous relatively minor simulation entities. Many of the editing screens now display user-selected units of measure. User input is accepted in the selected display units and converted into LRST's internal units. The edit dialogs now provide range checking on all input values with friendly, informative notification to the user when an input value is out of bounds.

The planar observers are also nearing completion, with LRST now providing for four types of planar observers: horizontal planar observers, vertical planar observers, range-boundary observers, and airspace observers. The first two types are simple planar observers. The third and fourth types are complex observers composed of sets of the simple planar observers. Provision has been made for a fifth type, a volumetric observer, with which a three-dimensional volume of space may be populated with observer points.

TASC reviewed the previous months HEL lab data to determine the optimum set-up for the remaining LRST validation experiments. We determined that a converging linearly polarized beam was best for comparisons of hand calculations with lab measurements. Furthermore, we determined that a circularly polarized collimated beam was best for comparisons of LRST predictions with lab measurements. We recommended additional flat plate scatter measurements at 30-degree laser incident angle and against a green painted target.

In regards to the PRA effort, TASC investigated applicability of a new laser beam scintillation model know as "gamma-gamma." Algorithms for implementation of the model are being developed. The model is being studied for its applicability to the PRA model, and used to examine scintillation effects in the NoDyCE LRST validation field test data.

Prior to burning final LRST installation CDs, we generated an installation package that included all of the new feature modules as well as a small collection of support tools from third-party sources. The tools included were the BRDF Tool for viewing material BRDFs, the Solids Modeling Tool (SMT) for creating and viewing target models, and a database repair tool (dtutil32) for fixing database problems (Borland Inc.). We obtained approval for using these tools from each respective developer. As a cross check on our cylindrical target lab measurements, TASC worked to obtain predictions using another laser scatter measurement model (called SVST). This model incorporates a high accuracy target scatter prediction algorithm. The SVST predictions showed the same trend as LRST predictions (based on our cylindrical target lab setup), but the SVST values were all lower than the LRST values for our specific test scenario. Assuming the SVST results are correct, this would imply that the LRST predictions are conservative (as planned for by design).

From July 8-11 TASC represented AFRL/HEDO at an ANSI Z136.1 bioeffects subcommittee meeting. We presented a briefing on the latest 1315nm wavelength laser bioeffects study. The goal for attendance at this meeting was to initiate efforts to convince the ANSI Executive committee that the 1315nm safe exposure levels are too high and should be relaxed in the next version of the standard. The primary benefit of this reduction would be reduced size of hazard zones for use of systems such as the High Energy Laser on the ABL aircraft. The subcommittee members expressed a desire to see 1315nm bioeffects data in the nanosecond pulsewidth range prior to reducing the safe exposure thresholds.

On the HEL Probabilistic Risk Assessment project, TASC has continued investigation of the application of the gamma-gamma model to atmospheric scintillation, and has developed preliminary algorithms to test against the NoDyCE flight test data. Although this model may look to have broader applicability for both weak and strong turbulence conditions, it suffers from difficulties in implementation with small numbers (low probabilities), and there is no inverse function, or a theory for averaging with large apertures. It is therefore likely that a preliminary model will be based upon the classical lognormal scintillation model.

In preparation for LRST training, Northrop Grumman prepared a new LRST release (version 1.1), and a high quality LRST User's manual and tutorial guide. Individual LRST CDs and manuals were prepared for each student. From 22 to 26 October, Northrop Grumman provided on-site LRST v1.1 training to Range Safety Officers at White Sands Missile Range (WSMR), NM.

Work has begun on adding a graphical interface to the Trajectory Editor. The graphical interface will allow the user to see the effects of modifications to the trajectory in a 3D display window. The graphical version of the Trajectory Editor will also provide a facility for animating the trajectory. Work also continued on the database migration tool and database repair utility. In addition, several missing database edit modules were added to the database editor. Deployment of the new (complete) database editor awaits the completion of the migration tool and the acquisition of a more powerful installation tool (InstallShield Professional).

In support of the LRST hypothetical scenario validation effort, Northrop Grumman developed a Maxwell-Beard Lambertian BRDF that will be tested in the hypothetical scenario. This BRDF was created by developing a set of reflectivity data files that emulate what an OCEL measurement of a Lambertian reflector would have produced, and then and used this data to extract the Maxwell-Beard parameters using the BRDF extraction tool. It is anticipated that the Maxwell-Beard BRDF will alleviate the asymmetries found when using a Phong Lambertian BRDF.

Northrop Grumman and AFRL/HEDO obtained confirmation that a letter granting an FDA military laser exemption for the laser systems on the Airborne Laser (ABL) aircraft has been approved by the FDA, AFIERA, and the ABL-SPO. A copy of the letter was sent to the ABL prime contractor, Boeing Aerospace Corp.

The Probabilistic Risk Assessment (PRA) Annex to the US-UK TRDP/MOU for Project Arrangement No. US-UK-AF-98-0029 was finalized. The Annex allows an informal exchange of information between US scientists and UK scientists on the subject of PRA for laser safety analysis.

In the HEL lab, Northrop Grumman examined options for converting the elliptical profile Nd:YAG laser beam to a circularly collimated beam. Such a beam is required for the next phase of cylindrical target scatter experiments which form a crucial part of the LRST simulation validation. A review of lab data from last year indicated a possible error in the beam profile software calibration values used. The spot size of a HeNe laser was measured using two techniques, a knife-edge and ribbon method, for comparison with IR camera spot size measurements. The two spot size measurement methods agreed within 20% and these data were used to obtain more accurate calibration constants. The next step will be to design an optical system to collimate the beam and provide a circular shaped beam profile at the cylindrical target. The use of a toroidal lens, cylindrical lens pairs with anomorphic prism pairs, and other techniques are being examined to determine the most cost and time effective option(s).

The Northrop Grumman V&V team completed a thorough investigation and detailed testing of the BRDF extraction tool. The primary goal of this effort was to determine why the LRST prediction for the reflectance peak of the diffuse aluminum plate at 30° angle-of-incidence is two times the peak value as measured in the HEL laboratory. Part of this investigation involved the first use of a modified version of the tool that allows BRDF extractions from target reflectance data from the Optical Measurement Facility (OMF) at WPAFB, OH. OMF data results compared surprisingly well with OCEL data obtained a few years ago, and indicate that a reevaluation of extraction process assumptions regarding apparent errors in the OCEL data may be warranted. The latest set of extraction tool test results show that there may be a breakdown in the Maxwell-Beard reflection modeling theory or an error in theory implementation in the extraction tool code.

Northrop Grumman completed an initial run through the continuous wave laser portion of the flat plate Lambertian scenario test matrix. LRST correctly calculated MPE levels at 1.064 microns over a range of exposure durations from 0.1 to 10s. An exposure duration of 0.05s was also tested and caused the program to crash. This result was expected, and verifies that 0.1s is the minimum time resolution capability for the simulation. The hazard zone sizes were found to match the hazard zone sizes for hand calculations. However, the LRST hazard zone locations were shifted as a result of the asymmetry in the irradiance scatter pattern reported last month. In addition, the first test of the pulsed LRST hazard analysis capabilities was completed. The results showed that for a 1.064μm laser with 5kHz PRF and 20ns pulse width, LRST correctly calculated the cumulative Multiple Pulse MPE for a 10s exposure duration.

Regarding the LRST V&V HEL lab effort, Northrop Grumman continued to collect and analyze laser scatter from the cylindrical and conical targets. Detailed investigation of data collected last month revealed that the diameter of the iris for our scatter collection system was incorrectly set. As such, select measurements were repeated as required and, in general, the new data showed better agreement with LRST predictions. The green painted target scatter plots versus laser incident angle showed trends that agree well with LRST predictions. The diffuse aluminum target scatter data showed larger differences from LRST predictions. These differences are most likely a result of the extraction tool inaccuracies that were discovered during flat plate diffuse aluminum target testing. In addition to the cylindrical target tests, a second set of measurements using the diffuse aluminum cone shaped target were made. During this test the observer plane was moved in closer to the target so the scatter signals would be large enough to measure. Finally, scatter along the vertical axis of the cylinder target was measured. This measurement was suggested as a way to do a 'quick check' to determine if the target reflectance characteristics (i.e., BRDF) of the cylindrical target were similar to the flat plate target.

The set of standard scenarios was completed. The standard scenario set consists of a matrix of thirty-six scenarios which are designed to bracket the range of materials (mirror finished to diffuse reflectors) over the complete set of standard targets (Lance, BlackBrant, TBM, and Storm) for each of the ranges (WSMR, Edwards AFB, and Vandenberg AFB). The standard scenario set is now part of the standard LRST database that is distributed with the software.

A rough-cut of the installation package was generated using the new installation builder, InstallShield Developer. Most of the components of the installation package were identified and a preliminary installation package generated. Several components of the distribution, which include the help file and the database repair tools, must be added to the installation package before it is ready for test installations. Work has also begun on the Import/Export tool so that it will run properly with version 2.0 of the LRST Database.

With regard to the HEL laser bioeffects effort, Northrop Grumman assisted in preparing for the 1.3µm skin study. Initial calibration of the HEL lab spectrometer was performed using a HeNe laser and Argon/Mercury lamp. Northrop Grumman support for this effort was transferred to Task Order #14.

On June 11, 2002, Northrop Grumman met with a contractor from Earthtech to assist in answering laser safety related questions in the ABL program Supplemental Environmental Impact Statement (SEIS). The original ABL EIS primarily considered hazards from the ABL HEL beam. In the SEIS, hazards from all four ABL laser systems that propagate outside the aircraft are addressed. We provided responses to all questions by Secretary of Air Force Headquarters and sent them to be included in the next revision of the SEIS document.

With regard to the development of the PRA demonstration software, integration of the LELAWS model into LRMS PRA was completed and LRMS PRA now has the capability of rendering a laser safety footprint with color scaling based on the probability of exceeding the MPE. Some problems were experienced in performance with the added calculation load. In order to enhance performance, range dependent calculations are now cached as well as only being done at one meter intervals versus one cm intervals. Screen shots from this preliminary version of LRMS PRA were used in a PRA presentation to the ABL SPO.

Dr. Megaloudis (Northrop Grumman, Reading, MA) provided valuable assistance for the LRST V&V effort. He developed a software tool (using MCAD) to provide estimates of the thermal signal at a given field test detector location due to thermal heating of targets during HEL illumination. In addition, he is researching IR cameras that can be used to image scatter patterns during future field tests (i.e., AFRL/DELE coupon testing). Finally, he is preparing a tool (again in MCAD) that will allow predictions of scatter from a cylindrical shaped target with Lambertian reflection properties. Results from this tool will be used to test cylindrical target scatter results from LRST as part of the LRST V&V hypothetical scenario effort.

Northrop Grumman assisted the ABL SPO with two separate consultative projects. First, responses to questions regarding the Laser Hazards section of the ABL Supplemental Environmental Impact Statement (SEIS) were prepared. Second, amendments were made to an FDA Requirements worksheet that Northrop Grumman had previously "custom tailored" to the ABL system. The revised worksheet was sent to the ABL SPO who then forwarded this to support contractors at Boeing.

In regard the HEL LRST V&V lab scatter measurements, Northrop Grumman completed the planned test matrix for primitive (flat plate, cylinder and cone) shaped targets. The final measurement sets included scatter measurement off the diffuse aluminum cone shaped target with the detector scan direction "in-the-plane" of the incident beam and a normal to the target surface, as well as "out-of-plane" scatter measurements. As with cylindrical target scatter data, our LRST predictions were in general lower than measured data for the cone shaped target. As a check on earlier lab V&V results, we repeated the 30-degree laser incident angle scatter measurements for the diffuse aluminum flat plate (conducted over one year ago) and demonstrated reasonable repeatability. The extraction tool must be validated and demonstrated to show accurate LRST agreement between flat plate measurements before we can draw any valid conclusions regarding comparisons of LRST predictions off the cylindrical and conical shaped targets.

Northrop Grumman continued parallel development of LRST versions 1.05 and 2.0. In LRST 1.05 we are improving the GUI as well as the physics code, and in LRST 2.0 we are restructuring the LRST database to improve program stability. We are on track to deliver a merged copy (LRST 2.1) of these two versions to the ABL SPO during their next visit in January 2003.

Northrop Grumman completed LRST v1.05 and LRST v2.00. Both code versions were submitted to the CVS repository and LRST v2.01 (alpha) is now running and ready to begin testing. LRST v1.05 includes a target collector point viewer that allows the user to see the size and location of the laser beam incident on the selected target. LRST 2.0 contains an improved database with all the requisite static data elements and constraints. The population of this database with the 36 standard scenarios and test scenarios from the LRST v1.0 database awaits the completion of the Import/Export tool being tested.

Northrop Grumman completed several key development tasks in the LRST 2.0 effort. The first task was the successful design, development and testing of the Database Backup/Restore Utility. This item is critical because it allows the user to get a previously saved version of the database if the current database becomes corrupted. This utility replaces the LRST v1.0 Database repair tool that cannot be used with the BLOB objects in the LRST v2.0 database. Northrop Grumman completed the interface between the Database Editors and the External Editors (atmosphere, boundaries, cities, etc.), designed and developed all required Database Editor screens (~35) and the interface between the Database Editors and the Trajectory Editor, and the Cyclical Redundancy Check (CRC) interface for all the Datafiles load utilities (this code prevents the user from inadvertently overwriting pre-existing data files).

In preparation for nanosecond 1315nm bioeffects studies, Northrop Grumman prepared a protocol amendment and submitted it to the IACUC committee. Once approval is obtained and the new laser installed and running, we are ready to begin bioeffects experiments at this wavelength and pulse duration.

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