ADDENDUM

to a

MEMORANDUM OF UNDERSTANDING

between the

INTERNATIONAL LINEAR COLLIDER
GLOBAL DESIGN EFFORT

and

The Lawrence Livermore National Laboratory

for the period

October 1, 2006 to September 30, 2007

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1. *Introduction*

This Addendum constitutes the Statement of Work to be performed by the Lawrence Livermore National Laboratory (LLNL) in support of the International Linear Collider (ILC) for the period of October 1, 2006 to September 30, 2007. During this time period it is anticipated that the baseline design for the ILC will be derived under the auspices of the GDE and a reference design report and cost estimate will be started. It is conceivable that during the time period of this Addendum more emphasis and thus more resources may be allocated to the R&D efforts described in this Addendum. Alternatively it is possible that more emphasis will be placed on the reference design report and cost estimate. Such decisions are expected to be made jointly by the GDE and LLNL within the context of the international collaborative R&D program.

The activities detailed in this document falls within the scope of the Memorandum of Understanding (MoU) between the GDE and LLNL dated Nov, 23 2005. The terms and conditions under which the work will be carried out are found within the MoU and are in force for the duration of time covered by this Addendum.

Work at LLNL for the period covered by this Addendum will primarily involve: design of a target for the positron source, engineering for the development of a Marx generator, development of fast kicker technology for the damping ring kicker, development of a coupler test stand at SLAC and beam instrumentation at ATF. A detailed description of the work to be performed will be developed by LLNL and the GDE as one of the first FY07 tasks. This description will include a summary of the manpower and costs as-

signed to each task. Funds at the level of $XM for ILC R&D will be established at LLNL in FY07 by transfer from the DOE as recommended by the GDE-Americas Region Director.

2. *Statements of Work*

This Section contains the Statements of Work to be done at LNLL during the period of time covered by this Addendum.

Statements of costs and commitments incurred for each work package will be submitted at the end of each fiscal year quarter to the GDE-Americas Regional Office.

Semi-annual technical progress reports for each work package will be submitted at the mid-point and close of the fiscal year to the GDE-Americas Regional Office. These reports will contain descriptions of technical progress, statements of goals for the next reporting period, and indications of long-range plans.

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Within two months following the end of the fiscal year, a final technical report for each work package will be submitted, in which the actual work accomplished will be compared with the scope defined in the work package in this MoU.

2.1 *Scope of Work*

The LLNL ILC R&D Program is subdivided in the following general categories and subcategories. A detailed WBS structure is being developed to track the ILC program, resources (both SWF and M&S) and milestone. These initial WBS could be redefined by the program managers as the program develops further in FY07.

3. Research and Development
- *3.2.1 Global systems*
  - *3.2.1.2 Fast Kicker development*
- *3.4 Positron Source*
  - *3.4.3 Positron Source Target Development*
- *3.7 Main linacs, including RF systems*
  - *3.7.1.2 Marx Modulator Mechanical*
  - *3.7.5.2 RF coupler test stand development*
- *3.8 Beam Delivery System*
  - *3.8.3 Nanometer Resolution BPM*
  - *3.X.X Laser Wire*
  - *3.X.X Beam Dump*

2.2 ***Definition of Work***

3.2.1.2 Development of a fast kicker for the damping ring injection/extraction

Motivation: The creation of a fast kicker is critical to the choice of damping ring size. A faster kicker enables a smaller ring with concomitant improvements in cost and reliability.

Description: An initial prototype was created and tested at the ATF in FY05. Work in this year will be to design and test new circuits for improved performance with the goal of updating the prototype.

Milestone and Deliverables:

FY07:
Build 3rd prototype
Test units at ATF

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Collaboration with Other Institutes: This work is to be funded under contract with SLAC and performed in collaboration with the SLAC pulsed-power group.

Key Personel: Ed Cook, Craig Brooksby

Cost Summary:

Labor (K$)	M&S (K$)	Indirect cost (K$)	Total cost (K$)
120	100	80	300

Expectations for FY08 and beyond:
This work is expected to continue into FY08 at the same level.

3.4.3 Positron source target design

Motivation: The positron target will be required to produce two orders of magnitude more positrons than has previously been achieved. This will require the development of an advanced target that will be able to handle the average and peak power as well as the radiation damage issues. A specification of the target and the handling of spent radioactive targets is necessary for engineering, costs and layout of the positron source facility.

LLNL has played a leading role in the development of rotating target designs for both a photon and electron beam based positron target. Previously, we have worked on the analysis of radiation induced structural failure of the SLC positron target.

Description:

1. **Complete Mechanical design** of Ti target wheel. CAD drawings. (Marty Roeben)
2. Complete vibration, and static stress calculations for the wheel due to wheel rotation and magnetic forces. (Lisle Hagler and Thomas Piggott)

3. **Collaboration with Liverpool University** and Daresbury Lab on building a prototype target and planning the set of experiments for the target. (Werner Stein, Thomas Piggott, Jeff Gronberg)
4. **1/2 size prototype target experiments** at SLAC. Plan, analyze, collect data, and direct an experiment to measure magnet forces on a rotating Ti wheel target. Facilities at SLAC will manufacture the wheel and acquire magnets and instrumentation and will provide personnel to run the experiment. (David Mayhall, Thomas Piggott, Werner Stein)
5. Pursue more **detailed studies of the Pulsed Magnet** design. (David Mayhall)
6. Perform more **detailed studies for the design of beam dumps** for the photon and electron beam lines. (Thomas Piggott, Werner Stein)
7. Pursue more **detailed studies of a photon beam tungsten target**. (Thomas Piggott, Werner Stein)
8. **Particle beam physics calculations** to determine shielding requirements, material activation, and radiation damage of equipment in the target hall for a photon beam interacting with the targets and beam dumps. (Susana Reyes, Jeff Gronberg)

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Collaboration with other Institutions: Studies within this work package will be coordinated with all other institutions working on the positron source. LLNL is presently collaborating on the positron source studies with SLAC, Daresbury and Liverpool. Work on calculations of radiation damage has been supported by contract with UC Berkeley.

Milestones and deliverables:

Mar 07: Mechanical design of ½ size prototype completed
Sep 07: Pulsed Magnet design, target and beam dump analysis complete

Key Personel: Werner Stein is the target design engineer. Jeff Gronberg is the Monte Carlo simulations physicist. Jeff Gronberg is the LLNL contact person.

Cost Summary:

Labor (K$)	M&S (K$)	Indirect cost (K$)	Total cost (K$)
600	60	400	1060

Expectations for FY08 and beyond:
The work in FY08 and beyond will focus on construction and analysis of target prototypes as well as ongoing optimization of the positron system to improve cost and reliability.

3.7.1.2 Mechanical engineering of a MARX generator modulator prototype

Motivation: A Marx generator modulator has the potential to improve the baseline for the klystron modulator systems. Compared to the current designs there is the potential

for; improved availability, lower unit cost, smaller physical size and possible reduction in cable plant.

Description: Work in FY07 will be mechanical engineering in support of the creation of prototypes and associated testing hardware.

Milestone and Deliverable:
Mechanical design of a full Marx modulator

Collaboration with Other Institutes: This work is in close collaboration with Greg Leyh and the SLAC pulsed power group.

Key Personel: Craig Brooksby, Ed Cook

Cost Summary:

Labor (K$)	M&S (K$)	Indirect cost (K$)	Total cost (K$)
102	130	68	300

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Expectations for FY08 and beyond:
Work in FY08 is expected to continue at the same level with focus on design for manufacturability.

3.7.5.2 Development of a Rf coupler test stand

Motivation: By developing an understanding of which components in the coupler design lead to long conditioning times and delicate operational stability, RF coupler designs for the ILC can be developed that are more robust and less costly, both to build and to condition.

Description: Eleven coaxial sections (40 mm ID, 70 Ohms) will be prepared that vary in terms of material (SS or Cu), bellows (none or 5 or 10 folds) and windows (with and without). A general purpose waveguide (WR650) to coax adaptor will be designed to power the test sections in vacuum (one pair of adaptors will be used for all the tests). The tests will be done at the Coupler Test Stand that is being built as part of the L-band project at the NLCTA. The test sections will be instrumented to detect electron and gas activity to gauge processing performance. We will assist with the 1.3 GHz test stand at FNAL.

Milestone and Deliverable:

Perform cost and fabrication analysis	Jan 2007
Develop conceptual design for improved coupler	Feb 2007
Develop detailed design	Apr 2007
Receive two couplers	Aug 2007
Test on L-Band test stand at SLAC	Sep 2007

Collaboration with Other Institutes: This work will be performed in collaboration with SLAC.

Key Personel: Brian Rusnak

Cost Summary:

Labor (K$)	M&S (K$)	Indirect cost (K$)	Total cost (K$)
120	0	80	200

Expectations for FY08 and beyond:
In FY08 we will apply the experience from the test stand to the optimization of the coupler design for the ILC RF.

3.8.3 Development of a Nanometer Resloution BPM system

Motivation: The development of precision BPMs capable of resolution at the Nanometer level would allow the testing of beam stabilization schemes critical to achieving luminosity at the ILC.

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Description: The alignment and metrology frame have successfully demonstrated ~10nm resolution. This system will be used as part of the STAFF project to demonstrate stabilization of two sets of linked BPM systems. We will provide support for the operation of the frame as part of this project.

Milestone and Deliverable:
Operation of the two linked systems at ATF.

Collaboration with Other Institutes: This work is in collaboration primarily with SLAC but also other institutions involved with the ATF program. Including LBNL, KEK, Queen Mary, and Oxford University.

Key Personel: Sean Walston

Cost Summary:

Labor (K$)	M&S (K$)	Indirect cost (K$)	Total cost (K$)
30	20	20	70

Expectations for FY08 and beyond: It is expected that this work will be concluded in FY07.

3.X.X Development of a Laser Wire System

Motivation: Emmittance measurements will be critical for high performance operations. Laser wire systems are required to achieve luminosity.

Description: We will determine if available laser architectures can create a train of laser pulses matched to the time structure of the ILC beam. We will layout an optimized focusing system for achieving a small spot size.

Milestone and Deliverable:

Dec 06: Analysis of available laser architectures and downselect
Mar 07: Conceptual design of focusing optics
Sep 07: Conceptual design of laser system

Collaboration with Other Institutes: This work is in collaboration with institutions involved with the ATF program. Including KEK, Queen Mary, and Oxford University.

Key Personel: Brent Stuart, Jeff Gronberg

Cost Summary:

Labor (K$)	**M&S (K$)**	**Indirect cost (K$)**	**Total cost (K$)**
150	50	100	300

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Expectations for FY08 and beyond: A layout of the laser system in FY07 would lead to a prototype system demonstration in FY08 and beyond, first on a test bench at LLNL and then transferred to ATF for beam tests.

3.X.X Beam Dump Design

Motivation: The beam dump will need to be able to handle issues of tritium production, beam window survival, and remote handling. We have experience in these areas from our work on the positron target and from designing beam dumps for the Rare Isotope Accelerator (RIA) project. An alternative to a water dump has been proposed, a much longer gaseous beam dump.

Description:

- Analysis of thermomechanical stress in the entry window.
- Determine tritium handling issues.
- Thermo-fluidic analysis of energy deposition in the gaseous target.

Collaboration with other Institutions: No direct collaboration.

Milestones and deliverables:

Mar 07: Entry window simulation and tritium handling issues
Sep 07: Preliminary analysis of gaseous target complete

Key Personel: Tom Piggot and Werner Stein for engineering analysis. Jeff Gronberg is the Monte Carlo simulations physicist.

Cost Summary:

Labor (K$)	M&S (K$)	Indirect cost (K$)	Total cost (K$)
120	0	80	200

Expectations for FY08 and beyond:

The work in FY08 and beyond will focus on the detailed engineering design of the beam dump system.

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3. *Execution*

3.1 *Effective Date*

This Addendum to the Linear Collider MOU shall become effective upon the latter date of signature of the Parties. It shall remain in effect until superseded or October 1, 2007 whichever should come first.

3.2 *Approval*

The following concur in the contents of this Addendum:

_____	_____
Gerry Dugan, GDE-Americas Regional Director	Jeff Gronberg, LLNL, ILC Program Manager
_____	_____
Date	Date

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