ADDENDUM

to a

MEMORANDUM OF UNDERSTANDING

between the

INTERNATIONAL LINEAR COLLIDER
GLOBAL DESIGN EFFORT

and

BROOKHAVEN NATIONAL LABORATORY

for the period

October 1, 2005 to September 30, 2006

(Revision 1.1, 2/16/06)

1. *Introduction*

This Addendum constitutes the Statement of Work to be performed by BNL in support of the International Linear Collider (ILC) for the period of October 1, 2005 to September 30, 2006. 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 BNL 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 BNL dated September 21, 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 BNL for the period covered by this Addendum will primarily involve conceptual design and R&D for the final focus magnet systems of a large crossing angle

IR for the ILC and accelerator physics issues involving topics such as vibration in the beam delivery system, and IP optics. A detailed description of the work to be performed will be developed by BNL and the GDE as one of the first FY06 tasks. This description will include a summary of the manpower and costs assigned to each task. Funds at the level of $600,000 for ILC R&D will be established at BNL in FY06 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 ANL 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.

Semiannual technical progress reports for each work package will be submitted at the midpoint 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.

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 ILC-Americas WBS

The ILC-Americas WBS categories are listed below. The work packages defined in the next section are numbered according to this WBS.

WBS	Description
1	Program direction and administration
2	Accelerator design, including RDR
2.1	Management
2.2	Global systems
2.3	Electron sources
2.4	Positron sources
2.5	Damping rings
2.6	Ring to Main Linac
2.7	Main Linacs: Optics, beam dynamics, instrumentation
2.8	Main Linacs: RF systems
2.9	Main Linacs: Cavities and Cryomodules
2.10	Beam delivery system
2.11	Conventional facilities

3 Research and development
- 3.1 Management
- 3.2 Global systems
- 3.3 Electron sources
- 3.4 Positron sources
- 3.5 Damping rings
- 3.6 Ring to Main Linac
- 3.7 Main Linacs: Optics, beam dynamics, instrumentation
- 3.8 Main Linacs: RF systems
- 3.9 Main Linacs: Cavities and Cryomodules
- 3.10 Beam delivery system

4 Engineering and cost estimation in support of RDR
- 4.1 Management, technical and engineering services
- 4.2 Global systems
- 4.3 Electron sources
- 4.4 Positron sources
- 4.5 Damping rings
- 4.6 Ring to Main Linac
- 4.7 Main Linacs: Optics, beam dynamics, instrumentation
- 4.8 Main Linacs: RF systems
- 4.9 Main Linacs: Cavities and Cryomodules
- 4.10 Beam delivery system
- 4.11 Conventional facilities

5 Infrastructure and test facilities
- 5.1 Management
- 5.2 Global systems
- 5.3 Electron sources
- 5.4 Positron sources
- 5.5 Damping rings
- 5.6 Ring to Main Linac
- 5.7 Main Linacs: Optics, beam dynamics, instrumentation
- 5.8 Main Linacs: RF systems
- 5.9 Main Linacs: Cavities and Cryomodules
- 5.10 Beam delivery system
- 5.11 Conventional facilities

6 Reserve

2.2 ***Scope of Work***

Specific work packages for the period of time covered by this Addendum are defined in this section.

WBS 3.10.4: Final focus quadrupole full length coil R&D

A short (20 cm) proof of principle coil suitable for use in a final focus quadrupole was built and successfully tested during FY05. Extending the coil length to that of a prototype (~200 cm) introduces issues of mechanical stability, principally sag under stylus pressure, of the support tube which will affect the accuracy of the conductor positioning and thus field quality. Initial engineering concepts to permit the construction of long coils with accurate wire placement will be investigated. It is not anticipated that any long coil fabrication will be attempted during FY06.

The Snowmass 05 Workshop indicated the desire to minimise the crossing angle while maintaining a separate extraction line. As the crossing angle is reduced then fringe fields from the final focus elements increasingly impact the outgoing beam. Self shielding coil patterns exist which minimise fringe fields. A short self shielding coil will be wound and tested during FY06. In addition, a short proof of principle sextupole coil with co-wound correctors, will also be fabricated and tested.

BNL will continue the study of vibration in superconducting magnets. Some knowledge of mechanical motion of the cold mass and the cryostat in a RHIC quadrupole is expected to be obtained as a result of the ongoing work in FY05 at BNL using a dual laser beam Doppler vibrometer. It is proposed to further develop the techniques for vibration measurements in cold magnets where the motion of the magnetic center of a quadrupole can be measured directly, instead of the mechanical motion. As part of this work, a short pick up coil of sufficient sensitivity will be built and tested in a RHIC quadrupole magnet. The necessary data acquisition and analysis system will be developed to analyze the coil signals. The vibration characteristics of the pick up coil itself will be characterized with the help of the laser vibrometer. The goal of this work will be to establish the feasibility of carrying out direct measurements of quadrupole field center motion at the level of ~1-10 nm at 1 Hz.

WBS 3.10.5: Conceptual Engineering Design

With the expected funding for FY06, detailed engineering design will not be possible. We will concentrate instead on concepts for the cryogenic interface and MDI issues, such as the anti-solenoid and Detector-Integrated-Dipole, for the final focus quadrupole packages of a 20 mrad crossing angle IP. In particular we will investigate options for reducing the size of the crossing angle to be less than 20 mrad. We do not anticipate any significant activities in regards to the design of the 2 mrad IP, tail-folding octopoles, or dump line elements in this period.

In addition to the baseline 20 mrad crossing angle design, a major effort will be to continue to develop technically feasible smaller crossing angles. Initial work at Snowmass indicated that final focus designs with an outgoing beam tube passing through the cryostat of the incoming final focus quadrupole, together with a self-

shielding quadrupole design can reduce the crossing angle to as low as 14 mrad. These designs will be refined during FY06 in collaboration with other members of WG4

The current GDE schedule calls for the creation of a reference design and associated cost estimate by the end of CY06. This will require significant effort in FY06. Under this scenario we would expect to provide contributions to the GDE reference design activities on a level of effort basis. Topics of interest span the superconducting magnets used in the beam delivery system.

2.3 Motivation:

The current design of the ILC beam delivery system is predicated on the use of specialized compact superconducting magnetic elements close to the IP. These efforts will specify and prototype a typical magnet. These kinds of designs are novel with demanding specifications and are not available from other projects.

2.4 Collaboration with other institutions:

While the magnet work is performed wholly at BNL, the conceptual design work is performed in collaboration with SLAC personnel under the leadership of Andrei Seyri.

2.5 Key personnel:

Brett Parker (conceptual design), K.C.Wu (cryogenic engineering), Mike Anerella, John Escallier, Andy Marone, Paul Kovacs (system engineering)

2.6 ***Cost summary:***

WBS element	**Labor (K$)**	**M&S (K$)**	**Indirect cost (K$)**	**Total cost (K$)**
3.10.4	163.3	25	131.7	320
3.10.5	161.7	0	118.3	280

2.7 ***Expectations for FY07 and beyond:***

Development work on the large crossing angle final focus quadrupole system will ultimately need to encompass the design, fabrication and testing of a prototype element since these elements are unlike anything existing today. It is estimated that this will require about 3 years to accomplish. In addition to hardware, conceptual design work is still on-going and this will lead to contributions to the GDE reference design. Since these machine elements are closest to the detectors it is inevitable the detailed integration with the detectors will become necessary at some point. Establishing the quench threshold on these compact direct wind magnets is a high priority goal since disrupted beam does impinge on the extraction line magnets. Continuation of the R&D program associated with vibration and associated motion of the magnetic field is planned for FY07.

It is conceivable that the beam delivery system test facility (ATF 2) planned for KEK will request superconducting quadrupoles as part of that system.

It is conceivable that the design of the small crossing angle beam delivery system may require additional SC compact quadrupoles of a similar style.

Certain features of the interface with the detectors may be implemented using specialized elements such as the dipole-in-detector (DID).

The proposed R&D plan for FY07 is outlined in the following table.

ILC R&D Topics for FY07

Topic	Comments	Approx Cost
Prototype QDO & Test	~3 year program, this would be year one: design + fabricate + test. ~ 6 FTE's + some materials	$1400K
Direct wind quench threshold	Energy loss from disrupted beam. Small test coil with SS heater, ties in with Mohkov's beam loss simulations	$100K

Topic	Comments	Approx Cost
	~ 0.5 FTE + some materials	
Vibration R&D	magnetic and mechanical motion, laser interferometer + magnetic probes. 1 FTE of effort + some materials	$200K
Accelerator Physics	Optics, continued conceptual design, DID's, Anti-solenoids, small angle IP, etc.. 1 FTE of effort.	$200K
Ref Design	Engineering design of the compact quad region: continues. Cryogenic simulation of the magnet. 1 FTE of effort	$200K
ATF2 magnets	?	?
Small Crossing Angle IP magnets	?	?

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, 2006 whichever should come first.

3.2 *Approval*

The following concur in the contents of this Addendum:

_____	_____
Gerry Dugan,	Michael Harrison
GDE-Americas Regional Director	BNL ILC Program Leader
_____	2/16/06
Date	Date