June 30, 2010

REPORT OF THE REVIEW PANEL FOR THE ASIAN SINGLE TUNNEL DESIGN STUDY OF THE ILC CONVENTIONAL FACILITIES IN MOUNTAINOUS REGIONS

Date and Location:	June 1-2, 2010 KEK Laboratory, Tsukuba, Japan
Review Committee:	
- Review Chair-person:	Victor R. Kuchler (GDE-CFS: FNAL)
- Reviewers:	John A. Osbone (GDE-CFS: CERN) Thomas W. Lackowski (GDE-CFS: FNAL) Larry L. Hammond (GDE-CFS: FNAL) Randal J. Wielgos (GDE-CFS: FNAL) Tracy Lundin (Hanson Professional Service Inc.) Tomoki Shiotani (Kyoto U./JSCE*) Takafumi Seiki (Utsunomiya U./JSCE) Hideaki Yasuhara (Ehime U./JSCE) Satoru Yamashita (U. Tokyo/ICEPP)
- Observer:	Tomofumi Koyama (Kyoto U./JSCE)
- Not able to Attend	Wilhelm Bialowons (GDE-CFS/GS-APM: DESY)
- Review Secretary:	Akira Yamamoto (GDE/KEK/AAA)

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1. Introduction

The Review Panel identified three objectives for this review:

- Evaluate the conceptual design work developed to date by the KEK Linear Collider (LC)-Conventional Facilities and Siting (CFS) Group in conjunction with the Advanced Accelerator Association (AAA) Civil Engineering (CE) Working Group
- Determine the consistency of the work with respect to the ILC-GDE Guidelines for SB2009/TDP-2
- Review the work package plan for the conventional facility (CF) design to be executed at KEK

The Asian effort to examine sample sites in the mountainous regions of Japan is part of Global Design Effort (GDE) for an International Linear Collider (ILC), a next generation High Energy Particle Physics Accelerator. Other sample sites are also being investigated in Europe and the Americas Regions.

The topography and geology of sites in mountainous regions present certain technical aspects when considering the tunnel and cavern construction necessary for a project like the ILC. It was clear to the panel that work produced by the KEK LC-CFS Group in conjunction with the AAA (Advanced Accelerator association for promoting science and technology) CE-WG represented a good deal of practical experience with the construction of underground enclosures in these mountainous conditions. The information provided in the various talks presented a good description of the status of the work completed to date. Prior to the review a list of questions was compiled and forwarded to the KEK LC-CFS Group to aid in the development of their presentations. These questions were grouped in the topics of Underground Construction, Mechanical and Cryogenic Systems, Electrical Distribution and Life Safety. All of these items were addressed in the information presented; some portions of the Asian design were more developed than others which is expected at this stage of the TDP-2 design process. This report provides the panel comments for each of these general headings as well as summary comments to conclude the report.

2. Underground Construction

One of the most important aspects of the Asian design for the ILC conventional facilities is the use of a smaller pilot tunnel in conjunction with the main single tunnel for the accelerator. This pilot tunnel serves several purposes. First, it is used as an exploratory means to understand the geology ahead of the main tunnel to better prepare for rock inconsistencies, fractures and faults, poor ground conditions, abrasiveness, water inflow rates, etc. This approach, it was explained, is an accepted standard method used in the construction of traffic and rail tunnels in Japan. Other uses for the pilot tunnel include providing aid in ground water drainage and dewatering of the rock mass around the main tunnel and the overall underground enclosure complex primarily using gravity flow assisted by a series of mechanical pumps to direct water to the gravity outflows. The pilot tunnel may also provide an alternate exit way out of the main tunnel to facilitate egress in the event of an emergency situation during construction of the main tunnel and operational periods when personnel are occupying the underground areas. Finally, the pilot tunnel also provides space for utility distribution along the length of the Main Linac tunnels. The configuration of main tunnel and pilot tunnel prompted several comments from the review panel that are summarized below:

- The pilot tunnel must be utilized to maximum advantage for the construction of the main tunnel. Rock conditions, water inflow rates, rock strength, fractures and fault information gained from the construction of the pilot tunnel must be made available in time to adequately respond for the construction of the main tunnel. A proper schedule will be needed to fully understand the minimum lead time needed to effectively use the information gained by the pilot tunnel.
- While it is an established method in Japan to use a pilot tunnel, its construction still represents a cost that is additional to that of the main tunnel. This cost needs to be fully understood and measured against its advantages, after tunnel dimensions have been optimized and a construction schedule has been developed. Some panel comments suggested that the pilot tunnel approach may be a bit too conservative.

- As with any underground project, knowledge of the geology gained by specific soil and rock borings and other investigation methods is essential to the decision for the construction means and methods to be employed in any project. Although it may be premature to suggest that a detailed investigation effort be undertaken at this time, once that information is available, the decision to use a TBM verses NATM approach (or other methods) should be revaluated. In some marketplaces, unless the Owner has specific reasons for requiring that a certain excavation method be used, the marketplace typically decides which excavation methodology will be used based on the space and schedule requirements anticipated by prospective bidders. This information will also have an impact on the types of lining that may be considered for the tunnels and the large underground equipment enclosures as well as a fundamental impact on the determination of excavation advancement rates and project schedule. The site investigation will also help to determine if the pilot tunnel is absolutely necessary. In addition, actual site investigation will provide information that can be used to predict initial rebound, settlement and movement in the detector hall with respect to the push/pull arrangement of the detectors.
- Main tunnel diameter will need to be decided upon as part of the new conventional facilities baseline for the Technical Design Report. This includes consideration of both the DRFS and Klystron Cluster alternative RF systems in the worldwide effort.
- Ground water infiltration is likely to be substantial during the construction and operation of the ILC underground enclosures. The outflow of water from the main tunnel and pilot tunnel seems to be reasonably well understood with primarily gravity outflows supported by mechanical pumping as needed. The mechanical portion of this system needs to be studied for redundancy or emergency power in the event of a primary power failure. Also the effect of the seasonal inflow of ground water needs to be studied in terms of variations in hydrostatic pressures and tunnel movement over time for different water inflow rates. The water inflow also needs to be considered when developing plans for grouting behind tunnel precast or cast-in-place lining systems.
- The main work to date has been focused on the main tunnel and pilot tunnel. Preliminary drawings were presented showing the detector hall and TBM access halls, however the mountain region sites require that electrical equipment, cryogenic equipment and helium storage, cooling towers (and in the case of the Klystron Cluster RF Alternative, the klystrons and related equipment) all be installed in underground caverns adjacent to the main tunnel. The caverns must be sized for the assembly and operation of all of the underground equipment, but the access tunnels to those caverns must also be sized to accommodate movement of these large pieces of equipment during initial installation as well as for maintenance and replacement. Configuration of these support systems should be coordinated with the appropriate Technical Area Systems to provide a complete understanding of the equipment and maintenance procedures for the various systems. The volume of underground construction, the mechanical and electrical systems and facilities for the installation of cryogenic equipment comprise the major cost drivers for the conventional facilities cost estimate. The cost impact of installing this equipment in caverns underground and the additional

pilot tunnel needs to be fully understood with respect to the reference design cost estimate.

- With most of the support equipment being installed underground and adjacent to the main accelerator tunnel, radiation shielding becomes an important consideration. If equipment needs to be accessible while the accelerators are running, radiation shielding will need to be carefully planned and installed to allow safe access to the various caverns and underground equipment.

3. Mechanical and Cryogenic Systems

The panel understands that the maturity of the mechanical and cryogenic systems designs is at a preliminary stage at this time. As mentioned above, the systems for removing ground water inflow from the main tunnel and pilot tunnel seem to be well understood, however more detailed design is needed for the dewatering of the rest of the underground caverns and the detector hall which are likely to have floor elevations below the invert of the main tunnel and pilot tunnel. For the mechanical and cryogenic systems, the information presented seemed to provide a good start to the design process, but more detail will be needed during the TDP-II effort. The following are some issues that should be addressed:

- A further study of the process cooling systems should include a review of the use of higher DT's than the 5^{o} DT presented for the secondary and tertiary water loops to reduce flow requirements
- The ventilation scheme for the process water cooling towers and the cryogenic compressor areas needs to be fully understood including the cost of additional shafts to the surface, air flow requirements, adequate tunnel size for the transportation of equipment and actual heat loads generated.
- With most of the technical and support equipment located underground, a comprehensive ventilation scheme will need to be developed to provide adequate fresh air and exhaust capabilities and to control air movement and pressure differentials between various area of the underground complex. It will also be especially important to include in this ventilation scheme the measures to be taken in the event of a catastrophic helium release.
- Further study is needed to investigate the possibility for moving the cryogenic compressors to the three surface plant locations.

4. Electrical

As with the mechanical and cryogenic systems, the electrical distribution system is also in the early stages of development. The panel had only a couple of comments:

- A reconciliation of the current heat loads presented needs to be completed with respect to the heat loads contained in the RDR. The RDR used 182 MW which did not include the cryogenic loads of 40-60 MW. The total heat load presented was 130 MW which included the Cryogenic loads.

- The configuration of the AC distribution system for the DRFS system is in development. All system components that could cause a single point failure should be evaluated for redundancy or other risk mitigation.
- The electric distribution system, including one-line diagrams, should continue to be developed including the identification and sizing of significant equipment. During that process, consideration of the actual physical sizes of the equipment should continue to be evaluated to determine required space for transportation, handling, assembly and operation.

5. Life Safety

While a great deal of work has been devoted to the implications of the main tunnel and pilot tunnel scheme for the Main Linac tunnels, a complete design for the entire underground complex will be needed before a comprehensive life safety and egress plan can be completed. This will need to be completed to confirm the viability of the installation of the majority of support equipment in underground caverns as opposed to a surface installation. The pilot tunnel will definitely prove to be an advantage in the development of the life safety plan. However, while the pilot tunnel provides a similar approach to exiting as was used in the RDR, the exit discharge length to the surface has increased significantly. This aspect of the life safety plan should be studied further. Additionally a design that allows access to the exit discharge without walking through the adjacent tunnel should be examined. The issue of an accidental helium release will also need to be a part of the life safety planning for the underground complex.

6. General Conclusions

A great deal of work was evidenced by the detail and content of the presentation provided to this panel during this review. It is very apparent that the conceptual design work being done by the KEK Linear Collider-Conventional Facilities and Siting Group in conjunction with the Advanced Accelerator Association is detailed and effective. The combination of these two groups has had a very positive influence on the Asian Regional CF effort and on the GDE CF effort in general. The design work described in the various presentations seems to be fully consistent with the design guidelines for SB2009/TDP-2. Although there is still much work to be done, the outline for the planned work through 2012 seems to compliment the work that has already been completed. It will be important to ensure that resources continue to be made available so that the work as outlined can be completed in a timely manner. A challenge to all regional CF efforts will be to complete a design and cost estimate, not only for the preferred RF alternative for each respective region, but for both the DRFS and Klystron Cluster RF alternative systems. While this is an additional burden on limited resources, it is nevertheless a condition placed upon the global CFS Group and should be equally shared in the worldwide effort.

It should also be noted that although the limits of the current design work have been noted in this report, it is by no means, an indication that the Asian CF effort is somehow at a different level than that of the Americas or European CFS efforts. All regions are at approximately the same level of design detail and continue to work closely as a global team, each region learning and benefiting for the work in the other two regions. We fully expect that close and successful working relationship to continue through TDP-2 and beyond. In fact the review questions that were generated prior to this review will also be used by the other two regions to assist in their respective regional design efforts. During the review process, some panel members also suggested that efforts be made to define specific criteria for the conditions (design goals) in the underground facilities including tunnel and enclosure sizes, humidity level, air pressure stability and similar parameters to serve as a design guideline for the CFS design effort in TDP-2. Under the coordination of the GDE Project Managers, area Systems and the CFS Group need to fully discuss and agreed upon these criteria early in the TDP-2 process.

So in conclusion, the panel would like to once again thank the presenters, the KEK LC-CFS Group, the AAA CE-WG, the JSCE and all of those who participated in this well planned and very successful review of the Asian CF effort. The accommodations and organization of the facilities for the review were excellent. To that end, the panel would like to extend a special thanks to Akira Yamamoto, our Review Secretary, for his efforts in coordinating and organizing this review as well as to all of those who also contributed this effort. Our sincere thanks go to you all for your kind hospitality.