Dear Nobu and the Change Request Board,

On the behalf of the Executive Committee (EC) and the Main Linac Area System Leaders, I would like to submit a new change request which is based on CCR #20 but contains a few changes and a number of clarifications. I believe that the CCB concern regarding CCR #20 primarily arose because of poor definition of the overall collider parameters, which is the responsibility of the EC and the RDR Management Board. I will attempt to clarify these below and will address the details of CCR #20 in reverse order, i.e. CCR #20c, 20b, and then 20a. The full description of CCR #20 will not be repeated in this new change request as that is available on the CCB website; this change request will only discuss the clarifications to CCR #20.

Before discussing the details of the change request, two points should be noted. First, this change to the ILC design is motivated purely by cost considerations. The CCR #20 reduces the capability of the ILC design and it would not be considered if there were not a significant cost savings associated with the change request. When considering changes of this form, it is very hard to compare the impact in terms of absolute savings. However, it is our belief that these changes are cost effective and the proposed modifications are less invasive that some others with similar cost savings.

Second, the RDR is a design for the ILC given our ***best estimates*** of performance and cost. At this point in time, a design that ***guarantees*** achieving all of the performance specifications cannot be developed – given the state of the R&D program, such a design would have a near infinite cost. Some margins and overheads can and have been included in the design to provide flexibility in operation but such margins and overheads need to be clearly defined.

CCR #20c:

Change request #20c, reduced cryogenic system size using the rationale that the uncertainty factor in the static heat load was unnecessary. The design included an overhead factor of 40% and an uncertainty of 50% for the static load and the total heat load can be written as:

$$Qtot = 1.4*(1.5 * static + dynamic)$$

The 1.5 factor is an uncertainty factor while the 1.4 is an overcapacity factor. Reducing the uncertainty factor to 0 reduces the cryogenic system capability by 13%.

The main objection to the 1.5 factor is that it is a design contingency which has not been included in other items such as gradient. At the time of construction, the static, as well as the dynamic, heat loads will be known and thus there will be no uncertainty. In cases such as this, we should use our best estimate and not implicitly add contingency, which we can do in the cost estimate (as a risk factor for example).

In part, the uncertainty factor was included to provide some margin against parameter variation. The baseline parameters for the collider require that an average accelerating gradient of 31.5 MV/m be attained in the accelerator cavities to reach the cms energy of

500 GeV. Given the variation in cavity and rf power source performance, it is assumed that some rf units will operate above this average gradient and some below. However, the length scale of these variations was not specified. The uncertainty factor provided some margin against an average gradient higher than 31.5 MV/m over the full cryogenic system length of roughly 2.5 km. This is not necessary. It is entirely consistent with the ILC goals to assume an average gradient over an individual cryogenic system equal to the average gradient in the collider of 31.5 MV/m. It is believed that this new definition of the average gradient will make CCR #20c acceptable.

CCR #20b:

Change request #20b reduced the rf overhead from 3.5% to 0%. This essentially is a redefinition of the operating energy of the ILC, since the 3.5% energy overhead was thought necessary to ***always*** (>99% of the time) achieve the design cms energy of 500 GeV and also provide energy feedback. Without the 3.5% energy overhead the full cms energy of 500 GeV could only be achieved when all rf units were operational. The ***routine*** cms energy is difficult to define because it depends on the detailed operating and repair scenarios. However, simple availability models, similar to those discussed by the CCB, would suggest that a cms energy within 0.5% of 500 GeV cms could be achieved more than 50% of the time. Furthermore, the full 500 GeV cms energy could be achieved when necessary given the extra effort to get all rf units operational. Finally, it should be noted that space had been left in the main linac tunnel so that the 3.5% additional rf units could be installed to recover the possibility of always operating at 500 GeV cms as requested by the WWS (see Appendix B2 in the response to CCR #20).

This change request has the largest cost impact but, as discussed, it is difficult to analyze in absolute terms. The EC believes that this change request is an effective cost savings and feels comfortable with the redefinition of the linac energy reach; the WWS appeared to feel similarly. A more detailed understanding of the energy reach, overhead, and linac operation will be calculated during the EDR.

CCR #20a:

The CCR #20a specified a peak gradient of 33.5 MV/m in an rf unit with an average current of 9.5 mA. As the CCB noted, this probably does not provide sufficient overhead for the rf losses and the LLRF system. We would like to redefine the linac parameters to have a peak gradient of 33 MV/m at an average current of 9.0 mA. In this case, the rf power required at the cavities of an rf unit is 8.02 MW which is halfway between the maximum required (8.28 MW) assuming that the LLRF losses add linearly and maximum rf power required (7.80 MW) assuming that the LLRF losses add quadratically – see the CCB estimate for 9-8-9 (20061123) Appendix A-1 in the response to CCR #20.

It is expected that this rf overhead will prove sufficient. During the EDR, experiments at the linac test facilities will demonstrate the capabilities and limitations of the rf distribution and LLRF systems. At the same time, detailed simulations of the collider energy gain need to be performed where the peak rf power is limited and which use realistic parameters for the cavities, LLRF, and rf losses. These experiments and

calculations will provide better estimates of the rf power requirements. If the rf power is too low to provide 33MV/m, it is expected that a small reduction in the average current will be sufficient to restore the peak acceleration gradient and any luminosity impact can be recovered with a corresponding reduction in the horizontal beta function at the IP.

The main linac had been designed with for an average beam current of 9.5 mA and a beam pulse length of 1.0 ms. Decreasing the average current from 9.5 to 9.0 mA causes the rf fill time to increase by ~6% or ~30 us. The beam pulse length will be reduced to keep the rf pulse length constant which keeps the heat and cryo-loads roughly constant.

The maximum rf unit gradient of 33 MV/m still allows for variation in the maximum achievable cavity gradient while still maintaining an average gradient of 31.5 MV/m within a 2.5 km cryogenic system as well as the main linac. In addition, we have enclosed (below) an updated set of 'nominal' beam parameters with an average current of 9.0 mA that exceed the design luminosity of 2e34; these parameters are consistent with the operating ranges in the sources, damping rings, bunch compressors and beam delivery systems.

Please don't hesitate to contact me with questions,
Tor

9.0 mA Parameters

N = 2.04e10
Nb = 2670
Tsep = 363 ns (472 1.3 GHz buckets)
Tbeam = 969 us
Iave = 9.0 mA

Gex = 1.0e-5
Gey = 4.0e-8
Bx = 20 mm
By = 0.4 mm
Sz = 0.3 mm

Lum = 2.1e34