Date: 1.03.2007
Subject: Technical Risk Assessment for ILC value estimate
Ref: RDRMB-07-01

Dear System Area Leaders,

The ILC Value estimate is expected to be externally reviewed in May of this year. In preparation for the review, we must attempt to quantify as best we can the uncertainty or *risk* associated with the current estimate. This is now our priority for the next two months.

General approach and rationale

For the purposes of this exercise, we have divided the analysis of the value risk into two parts:

- *Component Risk*: the uncertainty in the unit cost prices themselves, as produced by the Technical Groups;
- *Technical Risk*: the risk associated with a design feature of the machine, which relies on the positive outcome of either on-going or planned R&D.

Component risk can be attributed to many factors: maturity of design (engineering); market conditions (including manpower, raw materials); basis of estimate *etc*. These uncertainties are generally dealt with by a judicious choice of a contingency, based on the level of engineering design in the estimate. The Cost Engineers have taken charge of producing a quantitative assessment of this risk, working in close conjunction with the Technical and Global Group leaders.

The technical risk – as defined here – is fundamentally based on the assumptions in the many design decisions that have been made during the RDR process. This risk is best dealt with via the System Areas, and you (the SA leaders) are in the best position to identify, catalogue and evaluate the risks in your sub-systems.

The process should start by identifying the significant technical risks which are inherent in the current RDR design. In general, a risk is taken whenever a technical assumption is made in the baseline design. The risk is that the assumption is not correct. By identifying the major technical assumptions in the baseline design, we will have identified the major technical risks.

It is important to remember that our goal is to produce a risk/uncertainty for the value estimate. Thus the estimated cost impact associated with the risk is of paramount

importance. This is fundamentally different from the risk analysis that was performed for the US Technical Options Study[1], where the cost impact was not considered.

Many cost reduction measures have been made under the *assumption* that the increased risk will be mitigated by the positive outcome of the R&D. A good example is the removal of the second positron damping ring. In general we have reduced the cost of the machine at the expense of increased technical risk.

There are two categories of technical risk for which the cost impact needs to be considered:

- *Known or explicit technical risks*: the baseline design assumes that certain known problems will be resolved through the R&D program. In these cases, since the problems are known, an alternative design based on proven technologies can be devised, and the cost associated with the risk is just the cost differential between the baseline design and the alternate design. An obvious example here is the choice of gradient for the main linac.

- *Projected performance risk*: into this category go all assumptions that are based on simulations that cannot be directly confirmed or supported by the current R&D plans. Many of our luminosity performance assumptions fall into this category (emittance preservation and tuning in the Main Linac, for example). These types of risks are much harder to quantify in terms of cost impact, but the cost of *possible* mitigation (risk-reduction) measures can be estimated (adding additional diagnostics or instrumentation is an example).

When making such a risk assessment, two quantities must be evaluated:

- *Impact*: In this case, the impact will be quantified by the increased cost of having to adopt a higher cost but lower risk design;

- *Probability*: or likelihood that a design assumption is incorrect (R&D fails to achieve its goals), is necessarily more subjective, and will require your best judgment.

To assess the probability, a time frame for the R&D must be assumed. For the current value risk exercise (and in the absence of further guidance) we will assume that all R&D must be successfully complete within the EDR phase (end of 2009).

It is quite possible that an identified technical risk in the baseline may have more than one mitigating design alternative, each one with its own reduced risk and cost impact. Where possible all alternatives should be catalogued.

[1] http://www.slac.stanford.edu/xorg/accelops/. See chapter 8: Risk Assessment.

Some iteration across all the area systems will be required in order to balance these risk assessments. The RDR management board will coordinate this directly.

Methodology

There will be three effective stages to achieving the estimate of the technical risk:

1. Cataloguing the major technical risks for each sub-system, identifying the mitigating design modifications (including, where applicable, any possible impact on other sub-systems), and assigning an initial best-guess to the probability.

2. Assessing the cost impact for each of the alternative designs. This may require input from specific Technical or Global groups, and the RDR management board should be alerted if this is the case.

3. Consolidate and rationalize the results across the sub-systems to produce the final technical risk analysis. Here the RDR Management Board will coordinate across the area systems.

The following simple DR example (numbers are just placeholders) indicates the type of information and format required:

item	**Assumption/risk**	**Probability of Failure**	**Mitigating design change**	**Cost differential relative to baseline**
1	Clearing electrodes, plus vacuum chamber coatings, will suppress electron cloud buildup below threshold for design bunch spacing	50%	Add 2nd e+ ring	200 M ILCU
2	…			

General guidelines and deadlines

The short time available to us will limit the scope and detail of this analysis. A final analysis must be complete by the end of April, in readiness for external review. We must therefore attempt to restrict ourselves to the primary cost-driving risks (relative to each sub-system). **As a general guideline, only risk items associated with a cost impact of ≥20 M ILCU should be considered.** This cannot be a definitive study of the risks in the baseline design, and will at best provide only an indication of the cost impact associated with the primary technical risks. The number of line items (risks) is not in general expected to exceed a few items per area system.

To complete this rough analysis in a timely fashion, the Management Board has set the following deadlines:

- **Stage 1:** risk catalogue and initial probability estimates: **Tuesday March 13th**
- **Stage 2:** estimate of cost impact: **Friday March 30th**

- **Stage 3:**
  - WebEx meeting to discuss results as a group with RDR MB: **Tuesday April 10th**
  - Draft final report: **Friday April 20th** (week before the TTC/MAC meeting at FNAL)
- Final report: **Friday May 4th.**

The RDR MB will be responsible for producing the final report.

As always, if you have questions, suggestions or comments, please send them to rdr_mgmt@fnal.gov (please put the words 'Tech Risk Assessment' in the subject).

The RDR Management Board
01.03.2008