ILC Engineering Design

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Fermilab

3 main aims – (from Brian Foster, 1/07 MAC)

In order to achieve our goals we must:

1) ensure that the internal momentum of the GDE continues to grow and that the tasks the GDE sets itself allow scope for the enthusiasm and commitment of the *international ILC community* to continue to grow;

2) produce the *technical information* required and agreed by the contracting governments as necessary to proceed to approval of the project;

3) coordinate the *world-wide R&D programme* to give the optimum return on the investment of the contracting governments.

Introduction

- Engineering Design Report – to be delivered in 2010
- Supported by ‘Engineering Design Activity’ – which includes the above 3 aims
- ILC Executive committee EDR plan (03/07):
  - **Select work package structure generally based on ‘Area Systems’ alignment**
  - **Led by a ‘project manager’**
  - **who is supported by ‘project management team’**
  - **Convene an ‘EDR task force’**
  - **Set time line for transition from RDR management to EDR**
    - (Starts now)

EDR task force

- Hitoshi Hayano, Nobu Toge, Katsunobu Oide
- Bob Kephart, Ewan Paterson, Marc Ross (chair)
- Andy Wolski, Lutz Lilje
- + ILC Executive Committee

- Deliver an interim report 29.05.07 (DESY LCWS plenary)
- Complete 08.07 Korea ILCSC meeting

DRAFT CHARGE

- To study two or more possible technical project structures (WBS) for the EDR phase of the ILC. (n.b. really focus on one)
- The WBS models should be oriented around a central project management structure, lead by a single project manager.
- The WBS should break down into individual Work Packages, suitable for distribution to interested parties, who would then take on responsibility for the deliverables of that Work Package.
- The WBS models must have clear lines of responsibility and reporting, up to the top-level management.
- The WBS should naturally support (and drive) the ILC R&D program, which must be an integral part of the project.

COMMENTS on the charge - considerations of particular importance

- (from the authors)
- global nature of the project
  - **how well does the WBS/WP structure map onto a geographically distributed project, and**
  - **how will it function .**
- existing programs,
  - **funding,**
  - **regional/institutional stated interests,**
  - ***not necessarily be constrained by them*.**
- solicit and take input from the current RDR leaders (Area, Technical and Global System leaders)
  - **and R&D (and other) boards**
- find flexible solutions,
  - **allow natural evolution**
  - **support (and encourage) new groups to join later**

EDR Task Force

- in parallel to
  - **1) define the EDR effort and goals,**
  - **2) collect input from institutions, RDR teams, GDE boards and the community at large**
    - To date: Daresbury, SLAC, KEK, Fermilab …
    - more to come, CERN, Saclay/Orsay, DESY etc
  - **3) begin to define work packages, their inter connection (WBS) and an organizational plan.**
- Meet with groups at the DESY LCWS meeting in late May.

EDR definition

Goal: The primary goal of GDE activities will be to advance

(i) the technology,

(ii) the design and

(iii) the construction plans for ILC,

approval for construction can be sought in ~2010,

EDR will

(i) explain the capabilities of the technology at that time,

(ii) will detail the design of the machine and the construction plans, and

(iii) will present an updated value estimate.

The purpose of the EDR will be to facilitate:

- formal international negotiations at government level on (a) siting, (b) funding, (c) organization and (d) execution of the ILC project;
- preparations for construction on a timescale consistent with the start of construction in ~2012.
- Preparations for construction will include the production of final engineering designs of critical components, procurement, and (once the site is chosen) site preparation.
- The primary technical output from the activity in the Engineering Design Phase will be an integrated engineering design of the accelerator. This design must satisfy the energy, luminosity, and availability goals outlined in the ILC RDR, and must also be consistent with the value estimate presented in the RDR.

Engineering Design phase will include the following.

1. *Basic R&D* to demonstrate that all components ***can be engineered***
2. R&D into ***alternative*** solutions to mitigate remaining risk.
3. An ***overall design*** to allow machine construction to ***start within 3 years***,
4. selection between ***high tech*** options must be made to allow ***industrialization*** efforts.
5. A comprehensive ***value-engineering*** exercise must be conducted.
6. A complete ***value cost estimate*** for the machine must be provided, including a funding profile consistent with the project schedule.
7. A ***project execution plan*** must be produced, including a realistic schedule.
8. Designs for facilities shared between different “area systems”, and for site-specific infrastructure. The designs must include the level of detail needed for regions to estimate the cost to host
9. All necessary information must be provided to regions to evaluate project technical and financial risks in support of a bid to host.

Comments

- Any organizational structure implemented for the GDE during the Engineering Design phase must have the flexibility to accommodate this diverse range of activities, while providing effective mechanisms for communication and coordination.
- Activities that are research-oriented or more technical in nature will have a very different character from those that are more directed towards planning and costing, and may benefit from different organization.
- However, all activities will be related to all other activities in some way, with many complicated dependencies.
- Ultimately, everything has to come together in the EDR.

RDR and RD – 2006/7

- RDR Area, Global and Technical Systems
  - **Developed design, plan and costs**
  - **Assessed technical and cost risk**
  - ***The above gives much EDA guidance!***
- (Not a project organization;
  - **Communication / reporting channels need definition)**

- RD Board with associated task forces
  - **'top level' RD: quantifying, advising and (in one case) coordinating global RD**
    - Much ongoing RD not part of the task force process
  - **Strong overlap with Area Systems**

- Collect proposed EDR deliverables from the above
  - **Devise more tightly linked organization intended to accomplish these**
  - **(DESY LCWS)**

Example deliverables from RD S-Task Forces

Gradient:

- Achieve 35 MV/m (vertical test) with sufficient yield
  - **90% for ~ 100 cavities (includes second cycle)**
  - **Complete recipe and achieved reproducibility**
- Achieve 31.5 operational gradient in a cryomodule

Damping Ring:

S3 WBS	Work Package
2.1.1	Lattice Design
2.1.4	Low-Emittance Tuning
2.2.1	Impedance-Driven Single-Bunch Instabilities
2.2.3	Electron Cloud
2.2.4	Ion Effects
3.5.1	Fast Injection/Extraction Kickers

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	EDR			Approval		Construction							Commiss.
Constraints				LHC physics	total length frozen		tunnel & optics layout frozen		optics details frozen		tunnels ready for install-n		
Beam dumps	beam dump conceptual design and critical tests			pre approval		beam dump final engineering			b.dump design frozen	beam dump construction		beam dump installed	
crab cavity	design, build & test of conceptual phase control system; cavity fabrication; conceptual cryostat design; LLRF develop and test with single cells			design of cryostat; cavity integration; beam test of one cavity		beam tests of two cavities		final engineering		production		installed	
ATF2	ATF2 construction and installation. Start of commissioning		Commissioning	Beam size and optics results	Beam stability results	2nd phase, e.g. SC FD; smaller emittance & beam size		Instrumentation developments and tests at beamline					
Final Doublet	Engineering design; full length prototype; stability design study and initial stability tests			Stability tests & design optimization		final design		production		lab tests	installation and pre-commissioning		
Detectors	Conceptual design; selection of two concepts; continue design			Design optimization		final design and start of production		Construct, assemble and pre-commission on surface				Lower down & commiss.	
IR integrated	Conceptual eng. design of IR vaccum chambers; supports; pacman and moving shielding; cryogenic; service platform; detector moving system; cranes; etc.			Detailed eng. design of integrated IR with finalized choice of two detectors for final design		final design and start of production		pro					
Magnets	Optimization of number of styles; conceptual design of most magnets; definition of interfaces; Detailed design of low field and other special magnets; Vibration -wise design			Design and cost optimization; layouts with real space allocation, and detailed interfaces.		final design & needed prototypes		production			commissioning		
Collimation	Tests of collimation wakefields and beam damage tests; conceptual eng. design			Detailed eng. design; optimization & integration into beamline		final design & pre-production prototypes					installation and pre-commissioning		
Instrumentation	Develop laser wires; test feedback BPMs with secondary beam; conceptual eng. design			Detailed eng. design; optimization & integration into beamline		final design & pre-production prototypes		production			installation and pre-commissioning		
Vacuum systen	Physics and conceptual eng. design. Detailed design of IR vacuum chamber.			Detailed eng. design; optimization & integration of beamlines		final design		production			installation		

Beam Delivery EDR + ‘Deliverables’

Overall tentative schedule to get general idea. Detailed (and more accurate) tables for several systems will be shown

Prioritization for EDR

- Based on:
  - **Technical risk mitigation**
  - **Cost risk mitigation**
  - **Cost reduction**
  - **Preparation**

RDR risk assessment

- Not in the above order:
  - **Quantitative evaluation possible based on RDR Value estimate and plan**
- Mechanism?

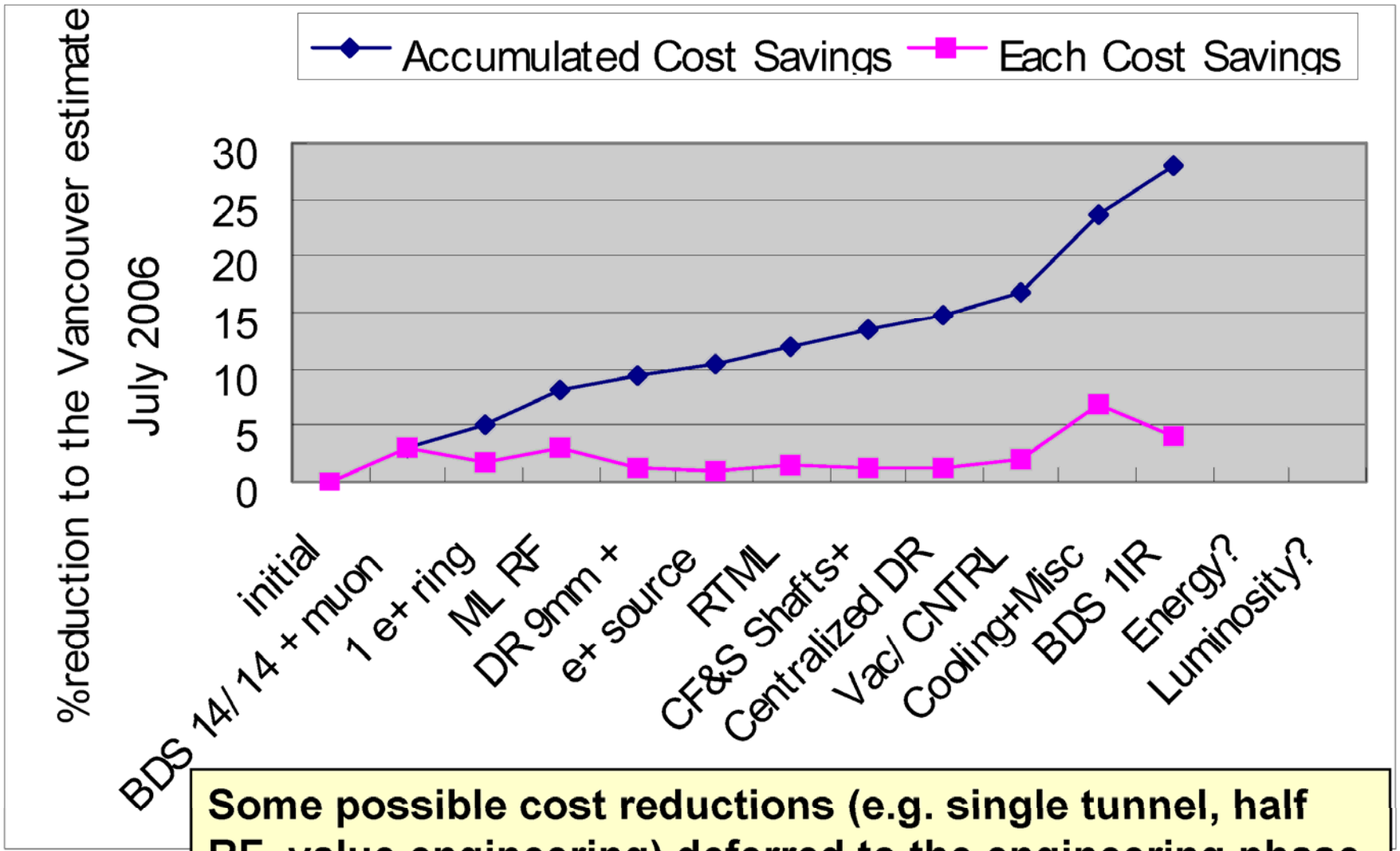
ED Activities for cost reduction

- Two cost drivers:
  - **Linac (2700M) and CFS (2550M)**
  - **Total 72%**
- Linac ?
  - **Work with XFEL**
  - **Continue to develop alternate strategies and examine mass production process**
- CFS
  - **‘Value engineering’**
  - **(US govt defined and mandated process)**
  - **Basic iteration between nascent design and emerging requirements**
- 10% of the above (525M) close to the max entry in RDR risk table.

How Good is the RDR Concept?

- The design has been carried out by Area Systems that have been built up into an overall design.
  - **We have advanced in integrating that design and even in being able to evaluate proposed changes that cross several area systems (e.g. central injector – E Paterson)**
  - **A more integrated design approach is envisioned for the engineering design stage.**
- Technical system designs still immature, resulting in lack of detailed specifications, requirements and value engineering has been deferred

Evolving Design → Cost Reductions



Some possible cost reductions (e.g. single tunnel, half RF, value engineering) deferred to the engineering phase

CFS – Value Engineering

- Value Engineering is a ratio: [cost /'worth'] iteration and minimization
  - **Similar terms: 'trade studies' and 'cost benefit analysis'**
- Single largest 'cost saving' realized in fall 06 RDR CFS review process
  - **'Cooling and misc'**
  - **30% of total 'saved'**
- Heat removal from SCRF distribution and power in two tunnel environment
  - **Also shafts, caverns and related underground**
- Air conditioning for access
- Flexible operation
  - **Interpretation of requirements included**

- CFS linac mechanical design not optimized

Present status:

- Demonstration of Internationally Driven RD / Design
  - **Extremely impressive / motivating / encouraging**
  - **RDB ‘advising’ funding US/UK/J FY07, EU FY08.**
- Must retain momentum
- RDR experience is valuable
  - **What worked / what did not**
  - **No one has done this before**
- Strong scientific leadership in place
  - **Need support, guidance, tools, resources…**

- *Ideal starting point for ED Activities*

Global Organization to do ED

- Devised along functional lines
  - (instead of institutional or regional…)
  - **With strong internationally balanc**
    - Experienced would be good…
  - **Alignment with funding wil cal (at first)**
- Relationship between R nstitute through a series of 'Memoran
- MOU defines a ge for a given Institution
- Above ma lar:
- *but thi ust be extremely careful to develop ar ter-regional consensus/balance*

??? You can hold institutions responsible for work packages and deliverables, NOT organizations built along functional lines without control of resources. Alignment of funding with work packages is the only way you get things done.

Responsibilities and Authority of EDR Project Management

- work should be *coordinated* through a more traditional project management structure
  - **What was missing in RDR organization? Clear commun**
- What content must be included in an MOU (or a agreement)…
    - (starting from the most important)
  - **Statements of work,**
    - What is to be done, agre ance through discussion with proje
  - **Milestones**
    - The sched and strategy
  - **Reportin**
    - In , both directions, third parties?
- En communication

Communication ? Sure… but most important is processes. These are what permit consensus building, or in the absence thereof, decision making.

above is taken as given, as achieved consensus

- **We must work through details.**
- **(This is not like a big lab or a big detector collaboration)**

Responsibilities and Authority of EDR Project Management(2)

- MOU contents:
  - **Management**
    - How are decisions made?
      - Especially selection between alternates, a kind of change control → to be included if change is below line
      - Advisory role of review / evaluation boards
      - Responsibility of project (line) management
    - What if there are problems? → technical strategy
  - **Commitment**
    - Institutional signature
    - Work package vs MoU ‘distribution’
      - » Only one institution for a given work package
      - » Several institutions for a given work package
      - » Inclusion of Alternate designs
  - **Communication mechanics**
    - Channel definition

Example KEK Work Packages:

- Cavity → TESLA like(1) and Ichiro (2)
  - **Alternates *included* in coordinated RD**
  - **Includes design work**
  - **And preparation for selection**
- Cryomodule design
- STF → S2/S1
- Damping Ring Kicker
- Electron Cloud (KEKB)
- CFS design

- Operation of ATF/ATF2 →
  - **different level coordination,**
  - **MOU exists, with boards etc…**
    - More like infrastructure development

ILC Partnerships: – MOU ++

- Who (institutions)
- Background (why and context)
- Task (work package)
  - **Subtask, schedules, milestones, deliverables**
  - **Resources**
  - **Contact persons**
- Updating mechanisms
  - **Reporting / tracking formalities**
  - **Meetings (face to face, phone, larger project)**
  - **Reviews**

Lesson from RDR

- Intellectual property ownership
- Responsibilities of signatories, including roles of boards
- 3rd party dependencies
- 'Alternates': selection mechanism
- Staff exchange, visits, PR
- Fungible (replaceable) assets / infrastructure to be used
- eDocument Management System
- Integration with technical systems

Organization

- Management section of WBS
  - **To include roles and tasks:**
    - Advisory Boards
      - R and D
      - Test Facilities
      - ?
    - Cost Engineering
    - Change Control
    - Standards / Integration
    - Planning / Scheduling
    - e Documentation / IT
- Familiar, yet not…

How are resources controlled?

- Where is the ‘funding agency link’?
  - **Two places:**
    - Behind the Institutional ‘MOU’ signature → each work package
    - RD advisory board → Strategic / Programmatic review
  - **This has to change as we reduce unknowns and move to action**
  - **Relies on patience and pro-active participation of teams**
- *Everyone must understand this three-way balance*
- Most expedient

Scope of EDR

- Proposed deliverables to be collected by TF at DESY LCWS (05/07)

1. R and D
2. Technical Design
3. Preparation for mass production
4. Cost and Plan
5. Civil Engineering

CFS USA – FY08

Planning Assumptions FY 08

- ***Establish CFS Role in the EDR Process***
- ***The GDE Project Management Team is Initiated***
- ***International Organization Begins to Mature and Develops a Method for Progress Reporting and Oversight***
- ***Begin to Refine the Preliminary CFS Schedule Through the Site Selection Process to the Start of Construction***
- ***Develop a Project Management Plan and Acquisition Plan for A/E Services***
- ***Prepare Engineering Requirements Document***
- ***Prepare CFS Configuration Design Control Document***

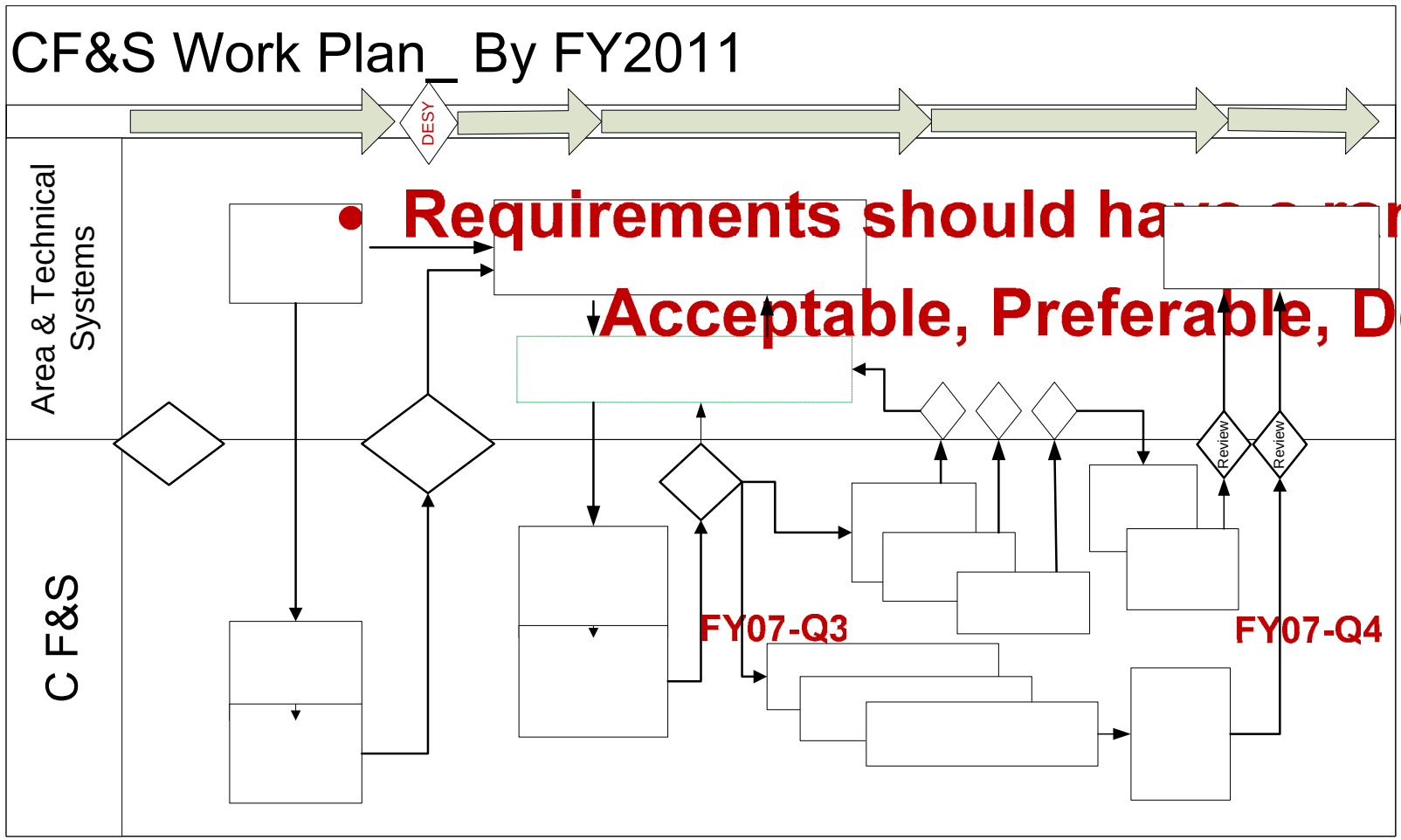
CFS USA – FY08

Planning Assumptions FY 08 cont.

- *Year One of a Three Year Process to Develop an Expression of Regional Interest*
- *CFS will Contribute to the Planning Process*
- *Will require Some Initial Site Specific Work that May Necessarily be Confined to the Fermilab Site*
- *Continue Underground Characterization with Northern Illinois University*
- *Resume the Underground Advisory Board*
- *Continue Public Outreach Efforts*
- *Initiate the Environmental Assessment of the Central Interaction Area*
- *Initiate Preliminary Geotechnical Study of the Central Interaction Area*

CFS work plan

Concept Design Must Be Based on Validated Requirements



- Requirements should ha nge
  - Acceptable, Preferable, Desir

Final RDR

Develop Fu

Preparation for mass production

- Tev was built here…
  - **Next machine?**
- Presently at the ‘threshold of technology’
  - **(For high gradient SCRF)**
  - **DESY is acknowledged world leader**
  - **XFEL project: June, 2007 start**
- Need to master, extend performance
- Ultimate goal:
  - **Reduce cost (~ 2x?)**
- Engage business, at several levels
  - **RHIC, LHC and MI experience**
- Develop models
  - **Include international connections**
  - **An extension of the global nature of the ILC**

EDR – an International Scientific / Engineering Collaboration

- Promote communication
- Define channels
- Provide valid review mechanics

- Attract expertise
- Facilitate an active environment
- Develop and promote enthusiasm

2007 – timeline for starting EDR

- March – EDR ‘straw-man’ organization, EDR Task Force
- April – RDR completion
- May – definition of EDR, collection of input at DESY
- July – presentation to FALC, first ‘roll-out’
- August – presentation to ILCSC, completion of EDR Task Force

Fermilab

- Managers and planner
  roles
- RD is just p
  operati
- Ci
-

Many practical questions:
What is the role of the EC in all of this ?
What is the role of the regional directors ? e.g. ART ?
How do you balance aspirations to host vs duplication of effort ?
Balance of Engineering design vs continued R&D
Balance of baseline vs ACD or cost reduction
Balance of regional interest vs global activities
Balance of continuing HEP program in U.S. and FNAL vs ILC EDR
What is FNAL's role in all of this ? (now vs 2010 ???)