Design & Cost Board Report

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March 9, 2006

Bangalore, India

outline of presentation

- WBS Progress (?) – Defining Construction Project
- What's IN/Out of Construction Project
- Desired Level of Detail
- Preliminary Construction Schedule
  for estimating needed production rates
- To Update RDR "Initial Questions for AS Groups"
- Cost Estimating "Deliverables" from AS, GS, TS
- Logistics: submitting WBS related info:
  expanding WBS elements, Dictionary,
  Basis of Estimate - examples
- DCB Parallel Sessions for Friday and Saturday
- Near-term Activities – DCB & Executive Committee

WBS Progress (?)

- Wiki: from dcb:dcb_home to dcb:dcb:prelim_wbs_illustrating_level
- WB_6feb06_PG_8feb06.wbs (SLAC Tool)

- **NOT** updated for Area–System-Discipline
- still System-Area-Discipline in many spots

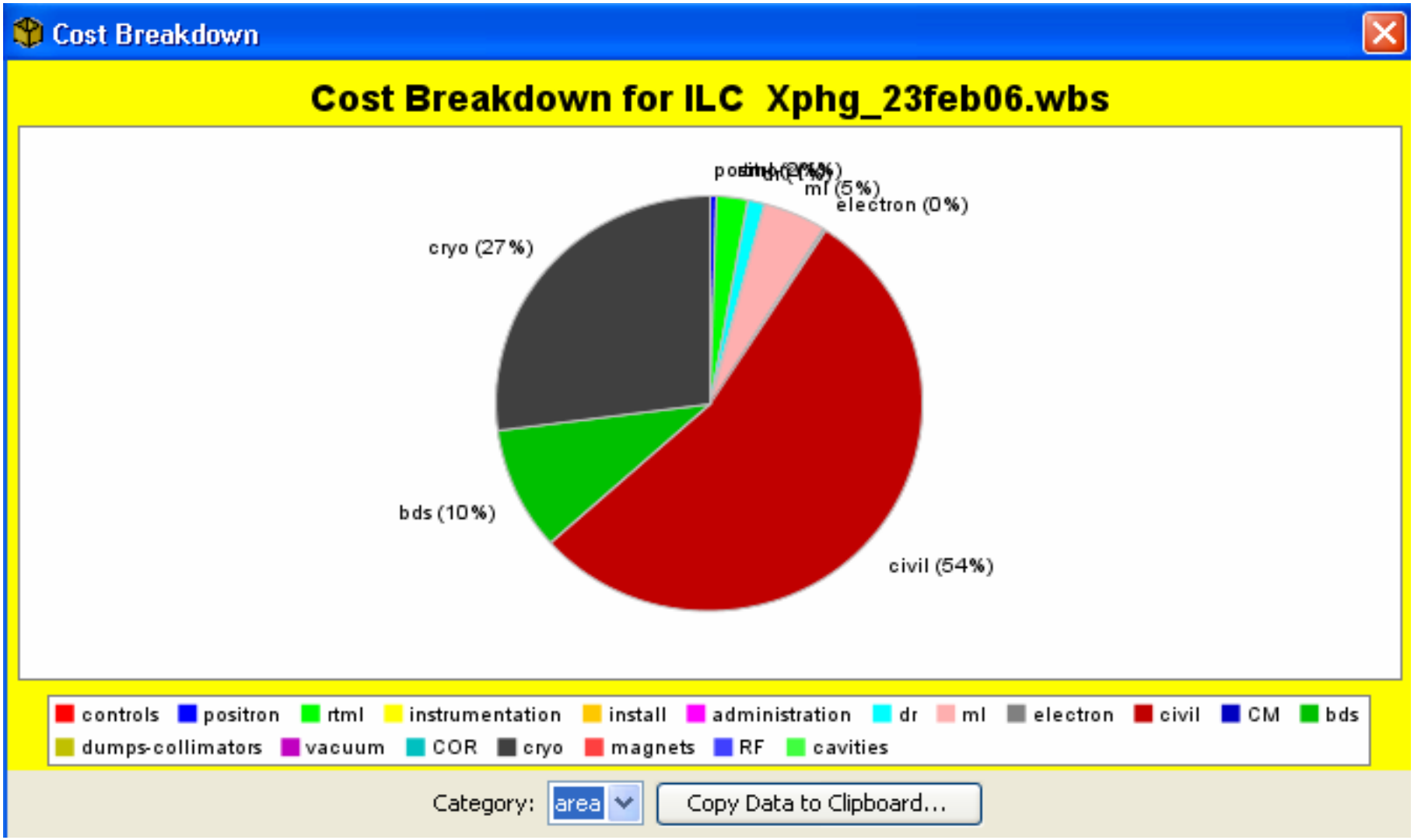
Wilhelm can illustrate projection of Areas using the tags

Example of Projection using Tags (dummy cost ests.)

WBS	Component	Number	Unit	Materials	Comment
1	ILC Xphg_23feb06.wbs		1 each	369,363	
1.1	Electron Source		1 each	100	@area=electron
1.2	Positron Source		1 each	200	@area=positron
1.3	Damping Rings		1 each	400	@area=dr
1.4	RTML		1 each	800	@area=rtml
1.5	Main Linac		1 each	1,600	@area=ml
1.6	Beam Delivery System		1 each	3,200	@area=bds
1.7	Commis, Op, Reliab		1 each	0	unique costs;@area=COR;@glob=COR
1.8	Control System		1 each	0	unique costs;@area=controls;@glob=controls
1.9	Cryogenics		1 each	100,063	includes all cryo costs here
1.10	Conventional Construction		1 each	263,000	includes all construction costs here
1.10.1	item civil	200,000	each	1	unique civil costs;@area=civil;@glob=civil
1.10.2	civil for e- source		1 each	1,000	@area=electron;@glob=civil
1.10.3	civil for e+ source		1 each	2,000	@area=positron;@glob=civil
1.10.4	civil for DR		1 each	4,000	@area=dr;@glob=civil
1.10.5	civil for RTML		1 each	8,000	@area=rtml;@glob=civil
1.10.6	civil for ML		1 each	16,000	@area=ml;@glob=civil
1.10.7	civil for BDS		1 each	32,000	@area=bds;@glob=civil
1.11	Installation		1 each	0	unique costs;@area=install;@glob=install
1.12	Vacuum System		1 each	0	unique costs;@area=vacuum;@glob=vacuum
1.13	Magnet System		1 each	0	unique costs;@area=magnets;@glob=magnets
1.14	Cryomodule		1 each	0	unique costs;@area=CM;@glob=CM
1.15	Cavity Package		1 each	0	unique costs;@area=cavities;@glob=cavities
1.16	RF Power		1 each	0	unique costs;@area=RF;@glob=RF
1.17	Instrumentation		1 each	0	unique costs;@area=instrumentation;@glob=instrumentation
1.18	Dumps & Collimators		1 each	0	unique costs;@area=dumps-collimators;@glob=dumps-collimators
1.19	Adminstration & Managemenl		1 each	0	unique costs;@area=administration;@glob=admin

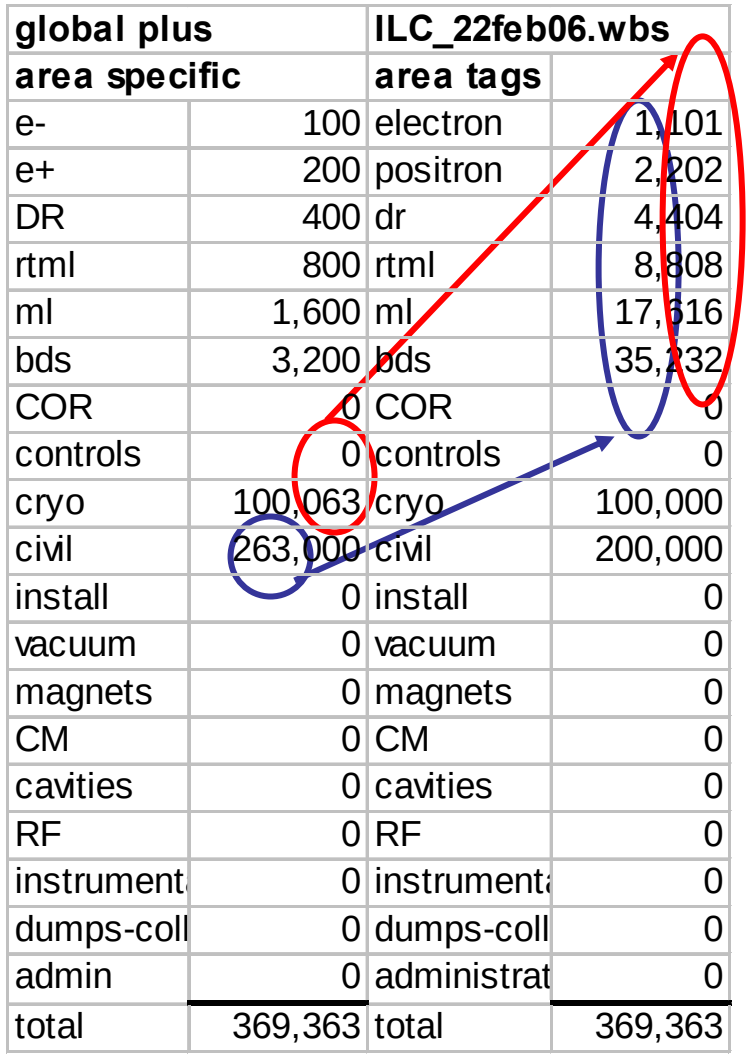
Component

Example of Projection using Tags



Project by Tags (dummy #'s)

global plus area specific		ILC_22feb06.wbs area tags	
e-	100	electron	1,101
e+	200	positron	2,202
DR	400	dr	4,404
rtml	800	rtml	8,808
ml	1,600	ml	17,616
bds	3,200	bds	35,232
COR	0	COR	0
controls	0	controls	0
cryo	100,063	cryo	100,000
civil	263,000	civil	200,000
install	0	install	0
vacuum	0	vacuum	0
magnets	0	magnets	0
CM	0	CM	0
cavities	0	cavities	0
RF	0	RF	0
instrumenta	0	instrumenta	0
dumps-coll	0	dumps-colli	0
admin	0	administrati	0
total	369,363	total	369,363



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e-	100	electron	1,101
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ml	1,600	ml	17,616
bds	3,200	bds	35,232
COR	0	COR	0
controls	0	controls	0
cryo	100,063	cryo	100,000
civil	263,000	civil	200,000
install	0	install	0
vacuum	0	vacuum	0
magnets	0	magnets	0
CM	0	CM	0
cavities	0	cavities	0
RF	0	RF	0
instrument	0	instrumenta	0
dumps-coll	0	dumps-coll	0
admin	0	administrat	0
total	369,363	total	369,363

Wilhelm's Notes on Cost Estimate
(at top of current WBS - notes and web-link)

http://www.desy.de/~bialowon/ILCWBS/ILCWBS(Note1).pdf

contains 23 statements,
definitions, assumptions, or
characteristics for the

ILC Construction Project Cost Estimate
and for its Work Breakdown Structure (WBS)

This is a draft, we will be refining, updating => DCB wiki

This **W**ork **B**reakdown Structure (WBS) is used for the Reference Design Report (RDR) "reliable" cost estimate by the end of 2006. The center of mass energy is 500 GeV. Essential components for the 1 TeV option are included. One common estimate of the "value" and labor including site dependent cost is made. The definition of the "value" is:

1. Cost estimate of the construction cost but no preparation cost.
2. Cost estimate on the basis of a world wide call for tender, i.e. the value of an item is the world market price if it exists. This also applies to the conventional construction and Consultancy Engineering.
3. The selection criterion is the best price for the best quality.
4. One vender supplies the total number of deliverables. Two vendors for the same package could be chosen for risk minimization. Then the parts depend on the bids.
5. If necessary parametric cost estimate is used for scaling of the cost, i.e. for cost improvement. The cost improvement is defined by the following equation:

$$P = P_1 N^a,$$

where P is the total price of N units, P_1 is the first unit price and a the slope of the curve related to learning [1]. The slope a is for large N also the ratio of the last unit price P_N and the average unit price $\langle P \rangle$.

6. No tax is included.
7. No escalation is used. The fixed date is January 2, 2007.
8. No contingency is calculated. The risk will be analyzed and assessed separately.

9. One currency with fixed exchange rates is used. The fixed exchange rates are:

$$1\ M€ = 1.2\ M\$ = 1.4\ Oku¥.$$

10. Fixed raw material prices, i.e. for copper, steel and niobium, and fixed prices for power are used.
11. The value is calculated parametrically for a given construction schedule in a certain range.
12. The external labor is included in the value.
13. Internal (institute) labor will be estimated in person hours.
14. The EDIA[1] is included in the item cost.
15. Site dependent cost due to real reasons is taken into account, i.e. different geology and landscape, availability of electrical power and cooling water different cycling rate of electrical power etc.
16. Site depending cost due to formal reasons are not taken into account. An International treaty above national laws will equalize the differences of the different regions.

[1] In the U.S. EDIA is the acronym for Engineering, Design, Inspection and Administration. Industry calls this non-recurring engineering (NRE).

17. No intellectual property rights have to be considered.
18. The cost estimate below level 2 (1.i) will not be public.
19. One common design including the footprint is used, unavoidable differences due to physical reasons are allowed.
20. A common set of rules, codes and laws which fits to the regional sets if the cost impact is negligible is used.
21. The use of ILC standards if necessary or the adoption after site decision with additional cost is recommended.
22. Additional regional options are allowed, i.e. use of existing machines or substantial cost savings.
23. Operation cost including commissioning and test with beams are calculated separately. Technical tests are included.

References

[1] Department of Defense, United States of America, *Joint Industry Government Parametric Estimating Handbook*, Second Edition, Spring 1999.

What is (in/out of) the ILC construction cost estimate?

- uses the spirit of ITER “Value” methodology
- Construction starts when funding authorized
- Construction ends for individual item when installed, before commissioning begins (not traditional U.S. definition)
- Does not include Research & Development
- But we need to compile estimates for R&D, commissioning, and operations (per year) for both costs and institutional labor

What is (in/out of) the ILC construction cost estimate? (2)

- Doesn’t include labor costs, but estimates of institutional labor effort in person-hours
- Doesn’t include contingency!
- Will need a risk assessment for costs.

WBS Level of Detail Desired

- Would like to have estimates in lowest level presented to ~ a few x 0.1% of total ILC
- Graded approach, put effort onto cost drivers
- You might need lower levels of WBS in order to produce your own cost estimate
- So far, WBS are trial-balloon examples, intend to modify to meet your needs
- Examples below are for Materials & Services (not internal labor) from USLCTOS

Level of Detail Example (1)

cryogenics_WBS_28feb06.xls

%				
	percentage of total materials cost for USLCTOS 500 GeV Cold option			
	these percentages for USLCTOS are somewhat sensitive,			
	they are listed just to give idea of level of detail that has been attained			
WB_6feb_PG_8feb (Follows USLCTOS)			This is what is on the web, the items 1.8.3.1.1.i	
1.8.3 Cryogenic Plant and Distribution			were omitted. The green numbers on left are	
4.08	1.8.3.1 Cryogenic Plants		percentage 4.08% of total USLCTOS 500 cold M&S	
3.27	1.8.3.1.1 Cryo Refrigeration Unit (includes cryo distribution, but not civil utilities)			
This layer was not included - consider adding this layer to increase sensitivity				
1.12	1.8.3.1.1.1 Cryo Cold Boxes			
0.68	1.8.3.1.1.2 Cryo Warm Compressor System			
0.12	1.8.3.1.1.3 Cryo Cold Compressor System			
0.11	1.8.3.1.1.4 Cryo Purification System			
0.13	1.8.3.1.1.5 Cryo Refrigeration System Controls			
0.10	1.8.3.1.1.6 Cryo Liquid Helium Storage			
0.17	1.8.3.1.1.7 Cryo Vertical Transfer Line			
0.16	1.8.3.1.1.8 Cryo Distribution Boxes 1,2,8			
0.11	1.8.3.1.1.9 Cryo Distribution Boxes 3,6,7			
0.16	1.8.3.1.1.10 Cryo Warm He Gas Header			
0.09	1.8.3.1.1.11 Cryo Vacuum Barriers			
0.19	1.8.3.1.1.12 Cryo System Installation Contracts			
0.04	1.8.3.1.1.13 Cryo Miscellaneous			
0.05	1.8.3.1.1.14 Cryo Feed Boxes			
0.04	1.8.3.1.1.15 Cryo End Boxes			
0.25	1.8.3.1.2 Cryo Cooling Towers			
0.04	1.8.3.1.3 Cryo Warm Helium Storage			
0.04	1.8.3.1.4 Cryo Helium Gas (initial charge) **- should this be operating, not construction?**			
0.00	1.8.3.1.5 Cryo Vacuum Barrier			
0.01	1.8.3.1.6 Cryo Feed Boxes			
0.01	1.8.3.1.7 Cryo End Boxes			
0.17	1.8.3.1.8 Cryo Load Controls			
0.30	1.8.3.1.9 Cryo Cold Bypass (1 kilometer) - what was this? fairly pricey!			
	1.8.3.2 Cryogenic Distribution **- actually included above 1.8.3.1.1.i - so can discard this element**			

Level of Detail Example (2)

RF_WBS_phg_1march06.xls

USLCTOS - 2003 - similar to WB_6feb_PG_8feb06.wbs				**% of hardware**
	(not including contract installaiton or CF&S for RF)			**from USLCTOS**
1.5. 8.1	**RF System**		894	15.70%
	1.5.8.1.1	Modulator	894	6.68%
no	1.5.8.1.2	Pulse Transformer not here		0.00%
	1.5.8.1.3	Klystron	894	3.68%
	1.5.8.1.3.1	Klystron Tube	894	3.10%
	1.5.8.1.3.2	Solenoid	894	0.28%
	1.5.8.1.3.3	Socket	894	0.06%
	1.5.8.1.3.4	Roughing Pump/Controls	894	0.08%
	1.5.8.1.3.5	Dry Nitrogen Backfill System	894	0.16%
	1.5.8.1.4	RF Power Distribution and Interlocks	894	2.97%
	1.5.8.1.4.1	High Power Phase Shifter	894	0.13%
	1.5.8.1.4.2	High Power Splitter	0	0.00%
	1.5.8.1.4 3	Intertunnel Waveguide	1788	0.10%
	1.5.8.1.4.4	Waveguide to Feed Cavity #1	0	0.00%
	1.5.8.1.4.5	Cavity Feeds	894	2.80%
need to add	1.5.8.1.4.5.1	Circulators	14304	0.53%
need to add	1.5.8.1.4.5.2	Power Hybrid Couplers	14304	0.38%
need to add	1.5.8.1.4.5.3	Wavegude Small Sections	14304	0.36%
need to add	1.5.8.1.4.5.4	Three-Stub Tuner	14304	0.76%
need to add	1.5.8.1.4.5.5	RF Bellows	14304	0.25%
need to add	1.5.8.1.4.5.6	RF Signal Couplers	14304	0.00%
need to add	1.5.8.1.4.5.7	Low Power Loads	14304	0.51%
move	1.5.8.1.5	Low Level RF	894	1.91%
need	1.5.8.1.6	RF Drivers	894	0.34%
need	1.5.8.1.7	Auxiliary Equipment	894	0.13%

Total RF

Major RF Items

Still >> few * 0.1% can they be reduced?

Level of Detail Example (3)

cryomodule_WBS_phg_7march06.xls

1.2	Cryomodule						% of hardware	
	1.2.1	Cryomodule		(same as above)			from USLCTOS	
		1.2.1.1	SC Cavity Fabrication					
			1.2.1.1.1	Material			**2.43%**	
				1.2.1.1.1.1	Niobium RRR 300			
				1.2.1.1.1.2	Niobium RRR 30			
				1.2.1.1.1.3	Niobium Titanium			
				1.2.1.1.1.4	Cryoperm			
			1.2.1.1.2	Resonator Production			**3.57%**	
				1.2.1.1.2.1	Resonator Machining			
				1.2.1.1.2.2	electron-beam welding			
				1.2.1.1.2.3	Resonator Assembly			
			1.2.1.1.3	Tuners			0.80%	
				1.2.1.1.3.1	Tuner Mechanics			
				1.2.1.1.3.2	Tuner Electronics			
				1.2.1.1.3.3	Piezo Tuner			
			1.2.1.1.4	Helium Vessel			**1.00%**	
				1.2.4.1	Titanium Vessel			
		1.2.1.2	SC Cavity Assembly (above 1.2.2)					
		1.2.1.3	Cryostat Assembly (below 1.6)					
		1.2.1.4	Cryostat				0.84%	
			1.2.1.4.1	Material				
				1.2.1.4.1.1	Black (Ferromagnetic) Steel			
			1.2.1.4.2	Vacuum Vessel				
		1.2.1.5	Cryostat Assembly				**4.14%**	
		1.2.1.6	RF Power Couplers				**3.48%**	
		1.2.1.7	HOM Couplers				0.13%	
	1.2.2	SC Quadrupole, Corrector, Instrumentation					0.27%	
		1.2.2.1	SC Quadrupole					
		1.2.2.2	Corrector Magnet					
		1.2.2.3	Beam Position Montor					
						total =	16.66%	

Additional Levels of Detail Needed:

16.66% CryoModules
- 2.43% SC Material
- 3.57% Cavity Fabrication
- 1.00% Helium Vessel
- 4.14% Cryostat Assembly
- 3.48% RF Couplers

4.08% Cryogenics
- 1.12% Cryo Cold Boxes (LHC plants)
- 0.68% Warm Compressors (single item)

15.70% RF Systems
- 6.68% Modulators
- 3.10% Klystrons
- 2.80% RF Distribution
- 1.90% LLRF

Σ = 35.44% USLCTOS Est.

Single unit, Big Ticket Items – optimize, re-specify?

Multi-component - labor intensive items – reformulate process

Elements of the Cost Model

Three types of costs:

site-dependent: what it would cost a region to host ILC sited in that region, 3-4 estimates

commonly produced items (global capability & competition, e.g. copper/steel magnets):
=> world market (lowest) costs (quality)

specialty, high tech items: cavities, klystrons, cryomodules, cryo plants, etc.
=> get estimates from all 3 regions for 33% and 100% of required quantities

Elements of the Cost Model (2)

- Cost Engineers & Executive Committee must determine how to select a value to be quoted for such items w/ multiple estimates
- Need estimates of most probable costs per WBS element and an indication of the anticipated probability distribution for costs.
- Median (50%), 25% and 75% points of this distribution (or 90% point for upper limit) account for non-symmetric, high cost tail

=> Risk Assignment for the cost estimate

Elements of the Cost Model (3)

- Watch out for Correlated Risks:

  labor costs,

  price of materials (e.g. steel),

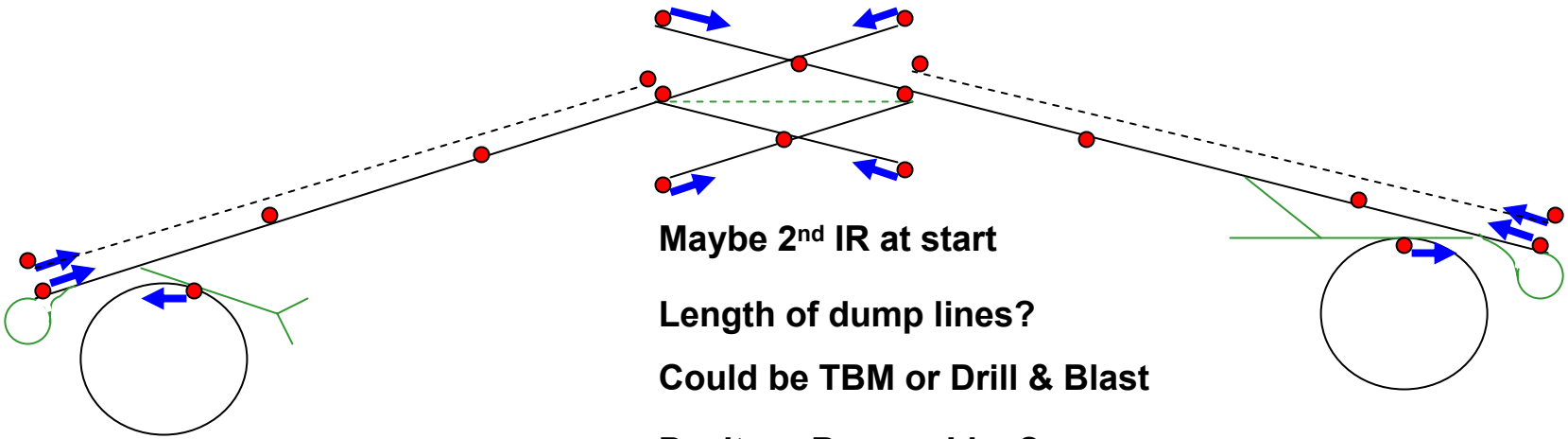
  price of electricity (for RF processing),

  etc.

Sketch of Civil Construction Activities

use only for sizing production capacities for components

(my own view – definitely not to scale)



Maybe 2nd IR at start

Length of dump lines?

Could be TBM or Drill & Blast

Positron Bypass Line?

Drill & Blast or TBM?

Shafts (many!)

TBM tunnels (8 or 10)

Outline of PHG Construction Schedule Model for generating component cost estimate

- 7 years – after funding authorization => t0
  through installation of all components
- need to start installation of components
  while civil construction continues:

t0+30 months: e- SRC, e+ Keep-Alive, RTML arcs

t0+33 months: DR t0+47 months.: start ML

t0+65 months: last sec ML & BDS

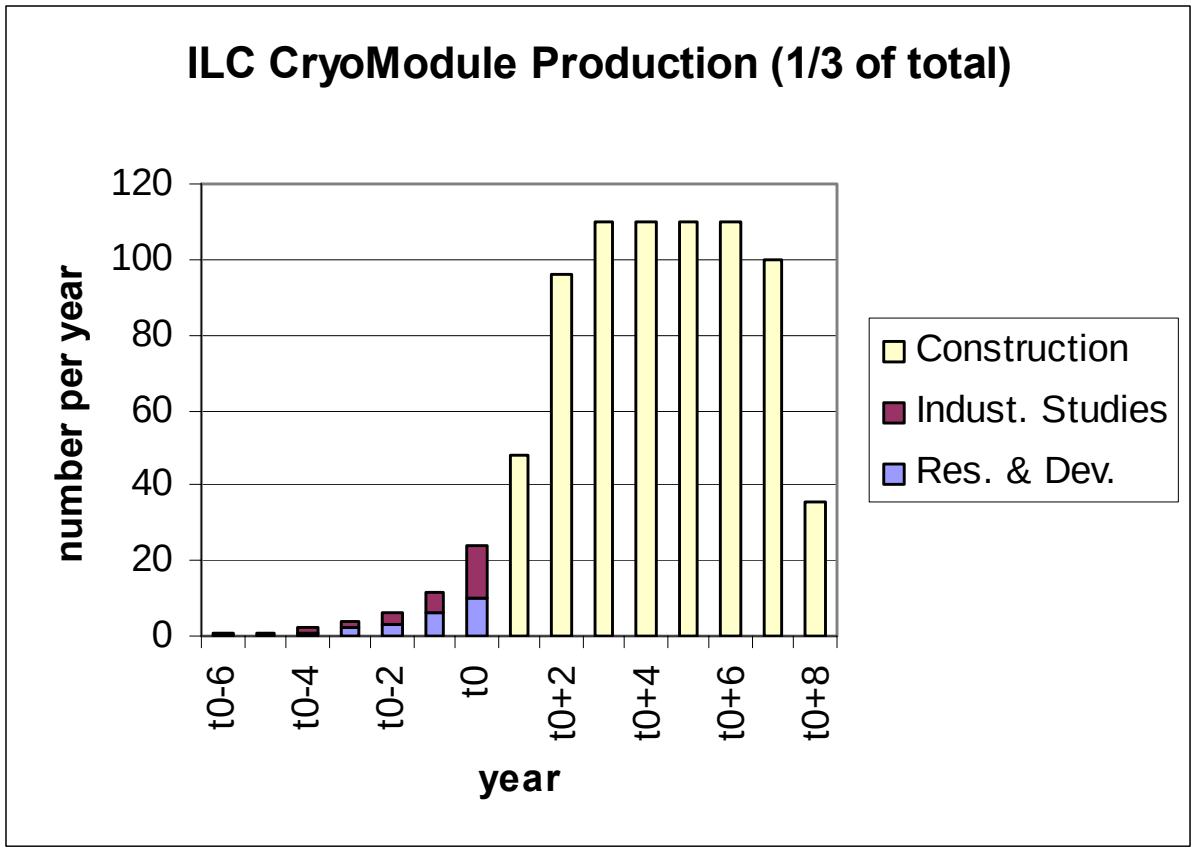
t0+78 mo.: t0+6.5 yrs.: last components delivered

t0+84 mo.: t0+7 yrs.: last component installed

Start Commissioning each sub-systems as soon as its components are installed

e.g. Impact on CryoModule Production

- Bob Kephart first guess at rate for 1/3 of total
- Ramp-up: R&D, Industrialization, Production
- **not fast enuf to complete in 7 yrs! need more plant capacity!**



“Initial Questions for Area System Groups” (6feb06 - currently on DCB RDR wiki) needs to morph into “Recipe for Delivering Cost Estimates”

- Define what is in/out of Cost Estimate

  Wilhelm’s list (on WBS web link)
- Step-by-step formula, instructions for what you need to do to provide information

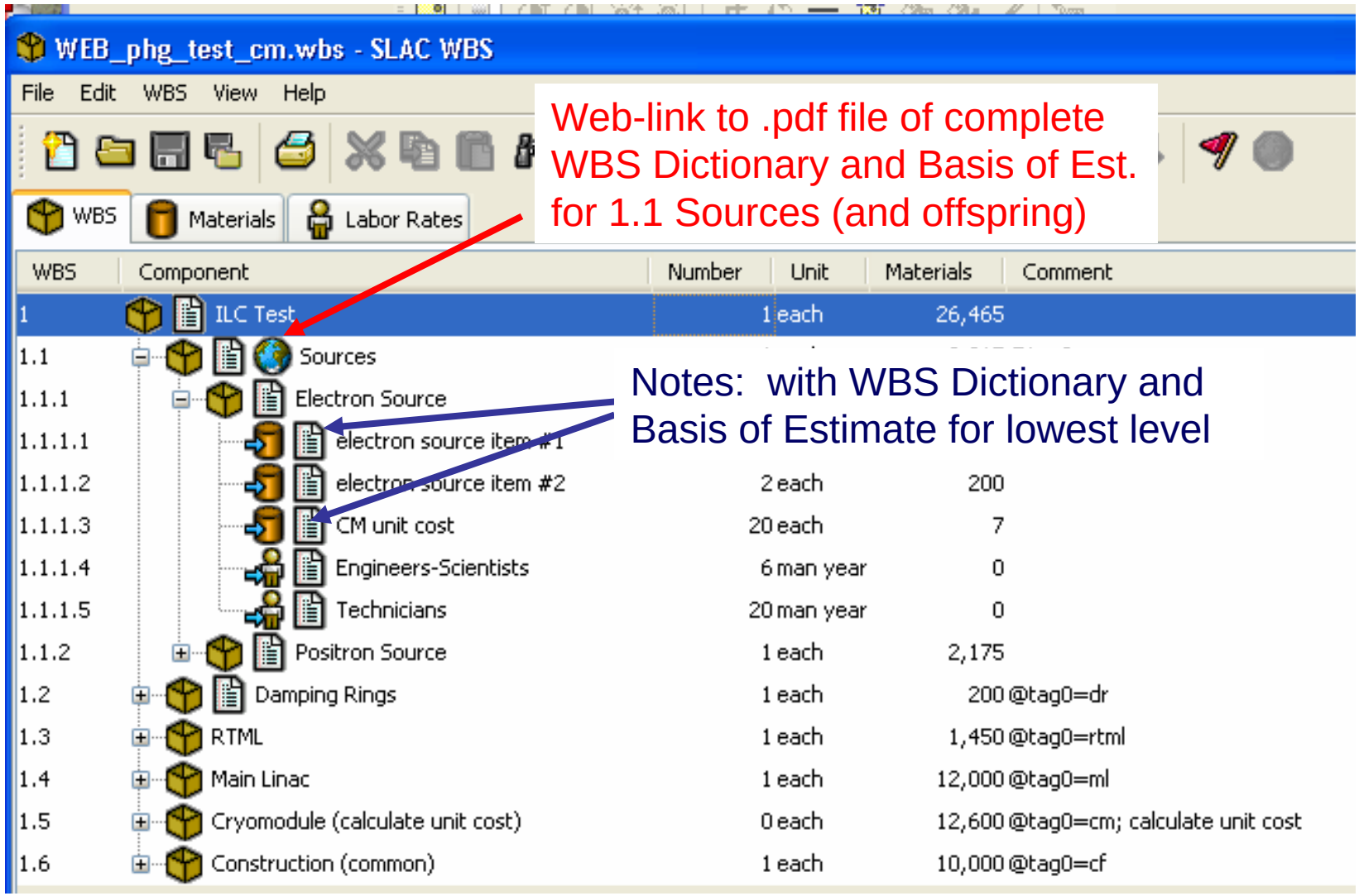
“Cost Estimating Deliverables”

- WBS structure modifications & additions which you need to produce cost estimate at required level of detail
- WBS Dictionary (description, boundaries)
- Basis of Estimate (will give template)
- Cost Estimate per unit (with uncertainty)
- number of units required – for cost table
- institutional labor est. – in person hours

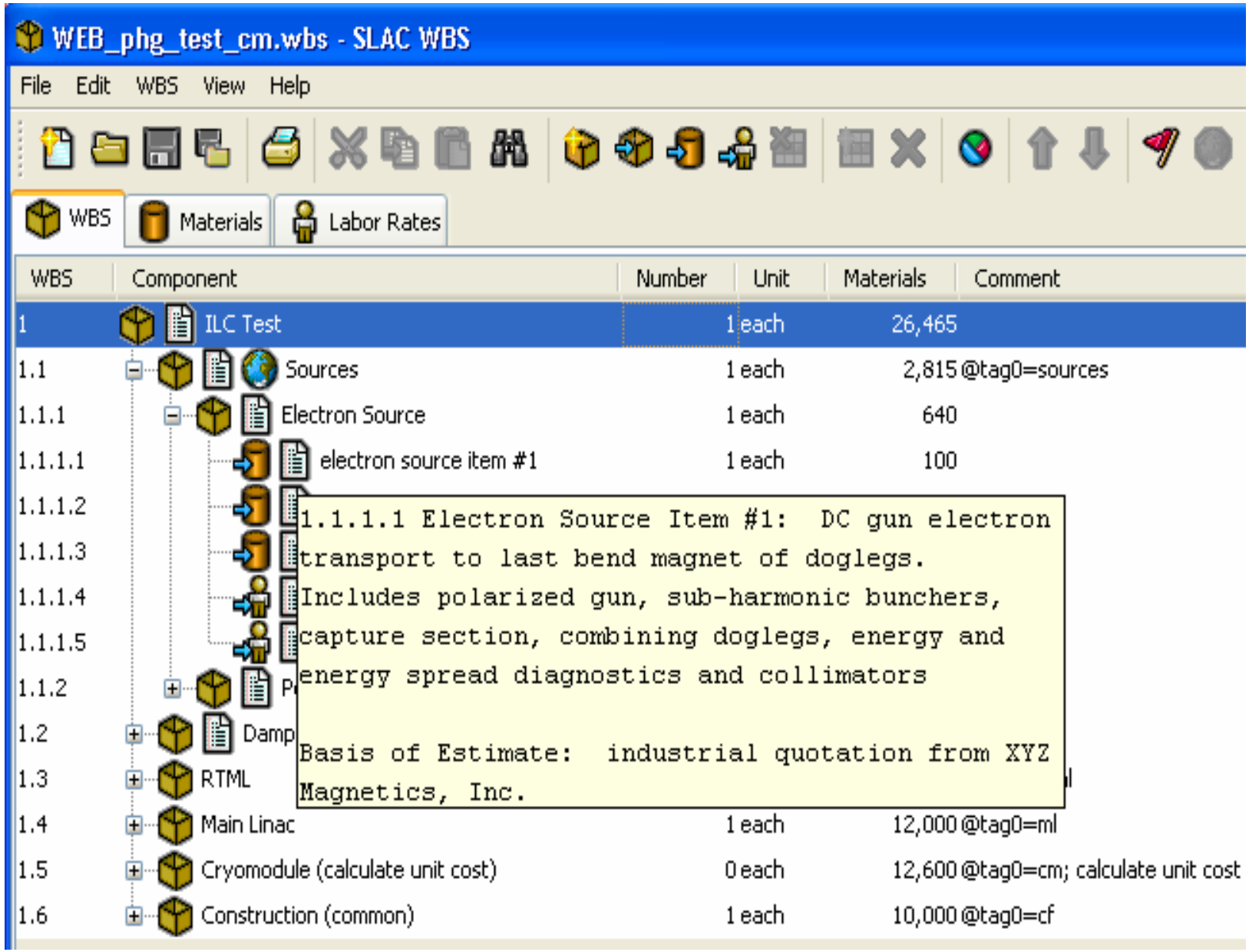
Logistics of WBS

- Responsibility of Area, Global, and Technical Systems Groups to provide "Cost Estimating Deliverables" to DCB
  (use an easy format for you:
  MS Word, EXCEL, text, etc.)
- Responsibility of DCB to get all that information into the WBS format.
- Here's an example of how we'll do it:

Example of WBS Format & Info



WBS	Component	Number	Unit	Materials	Comment
1	ILC Test	1	each	26,465	
1.1	Sources				
1.1.1	Electron Source				
1.1.1.1	electron source item #1				
1.1.1.2	electron source item #2	2	each	200	
1.1.1.3	CM unit cost	20	each	7	
1.1.1.4	Engineers-Scientists	6	man year	0	
1.1.1.5	Technicians	20	man year	0	
1.1.2	Positron Source	1	each	2,175	
1.2	Damping Rings	1	each	200	@tag0=dr
1.3	RTML	1	each	1,450	@tag0=rtml
1.4	Main Linac	1	each	12,000	@tag0=ml
1.5	Cryomodule (calculate unit cost)	0	each	12,600	@tag0=cm; calculate unit cost
1.6	Construction (common)	1	each	10,000	@tag0=cf


WEB_phg_test_cm.wbs - SLAC WBS
File Edit WBS View Help
WBS Materials Labor Rates
WBS Component Number Unit Materials Comment
1 ILC Test 1 each 26,465
1.1 Sources 1 each 2,815 @tag0=sources
1.1.1 Electron Source 1 each 640
1.1.1.1 electron source item #1 1 each 100
1.1.1.2
1.1.1.3
1.1.1.4
1.1.1.5
1.1.2
1.2 Damp
1.3 RTML
1.4 Main Linac 1 each 12,000 @tag0=ml
1.5 Cryomodule (calculate unit cost) 0 each 12,600 @tag0=cm; calculate unit cost
1.6 Construction (common) 1 each 10,000 @tag0=cf
1.1.1.1 Electron Source Item #1: DC gun electron transport to last bend magnet of doglegs. Includes polarized gun, sub-harmonic bunchers, capture section, combining doglegs, energy and energy spread diagnostics and collimators
Basis of Estimate: industrial quotation from XYZ Magnetics, Inc.

Example of WBS dictionary and Basis of Estimate (for cost-estimated items)
highlighted sections are Peter's notes to authors

1.1 Sources: (dictionary for WBS element) provides electrons and positrons to the Damping Rings (define general boundary)

1.1.1 Electron Source: from polarized electron gun to electron Damping Ring injection (from ILC BCD Beamline Descriptions)

1.1.1.1 Electron Source Item #1: DC gun electron transport to last bend magnet of doglegs. Includes polarized gun, sub-harmonic bunchers, capture section, combining doglegs, energy and energy spread diagnostics and collimators (define more specific boundary, and say what's included in element)
Basis of Estimate: industrial quotation from XYZ Magnetics, Inc.

1.1.1.2 Electron Source Item #2: EBSTR: from exit of warm pre-accelerator section to entrance of first ELTR bend magnet. Includes 3 matching sections and 4-wire 2D emittance diagnostic section
Basis of Estimate: QQQ-lab engineering estimate, built similar item recently

1.1.1.3 Cryomodule: standard cryomodule
Basis of Estimate: use unit cost for CM developed in item 1.5

DCB Parallel Sessions
Schedule – Locations?

- Friday – 11:00 – 12:00 – meet with Executive Committee
- Friday – 12:00 – 13:00 – meet with AS, GS, TS
- Saturday – 14:00 – 16:00 – meet with AS, Gs, TS
- Detailed time schedule? 14 groups over 3 hours
  => 12 minutes each
- Just stop by when you have a chance to talk

DCB Parallel Sessions

With Area Sys, Global Sys, Technical Sys Leaders

Do you understand what we are asking for (what is expected)?

Have you established/negotiated boundaries of responsibility
both horizontally (AS to AS)
and vertically? e.g. Installation vs. TS,
Controls vs. TS and Cryo, Instrumentation vs. TS and Cryo,
Alignment and Safety Systems (machine and personnel)

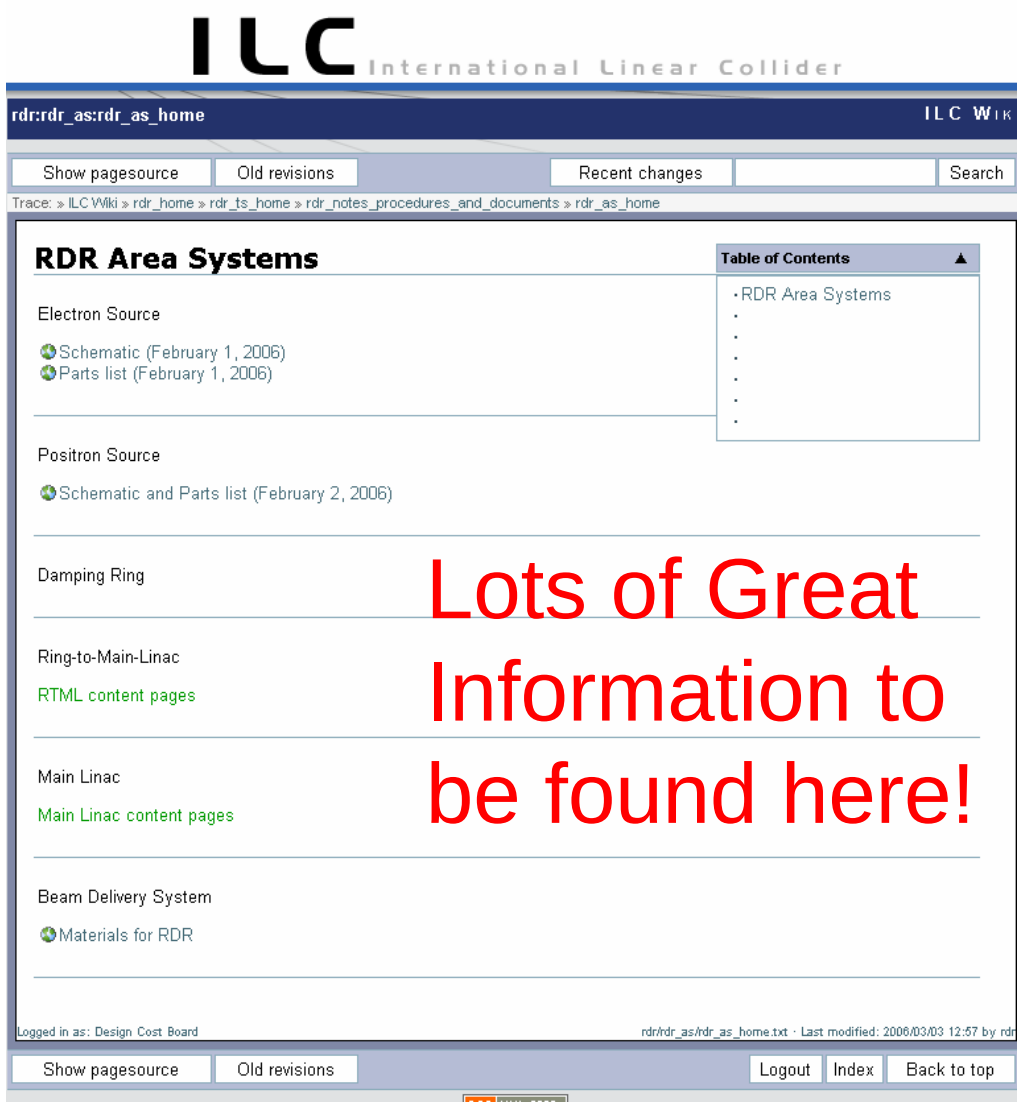
Have you produced and distributed your component list?

Have you reviewed the preliminary WBS that DCB sent a month ago?

Have you considered suggested changes or additions in this WBS
to better meet your needs of producing the cost estimate
and providing the level of detail desired? (few x 0.1% per item)

Can you produce the preliminary cost estimate
on the schedule of late-June?

RDR: AS, TS(0), GS(0)



Lots of Great Information to be found here!

Near Term Activities for DCB

- Refine WB's Cost Estimate Definition List
- "Initial Questions for Area System Groups"
  needs to morph into
  "Recipe for Delivering Cost Estimates"
- with Executive Committee, form joint
  schedule and procedures for
  reviews and milestones