Cost Management Report

John Carwardine

5 June, 2008

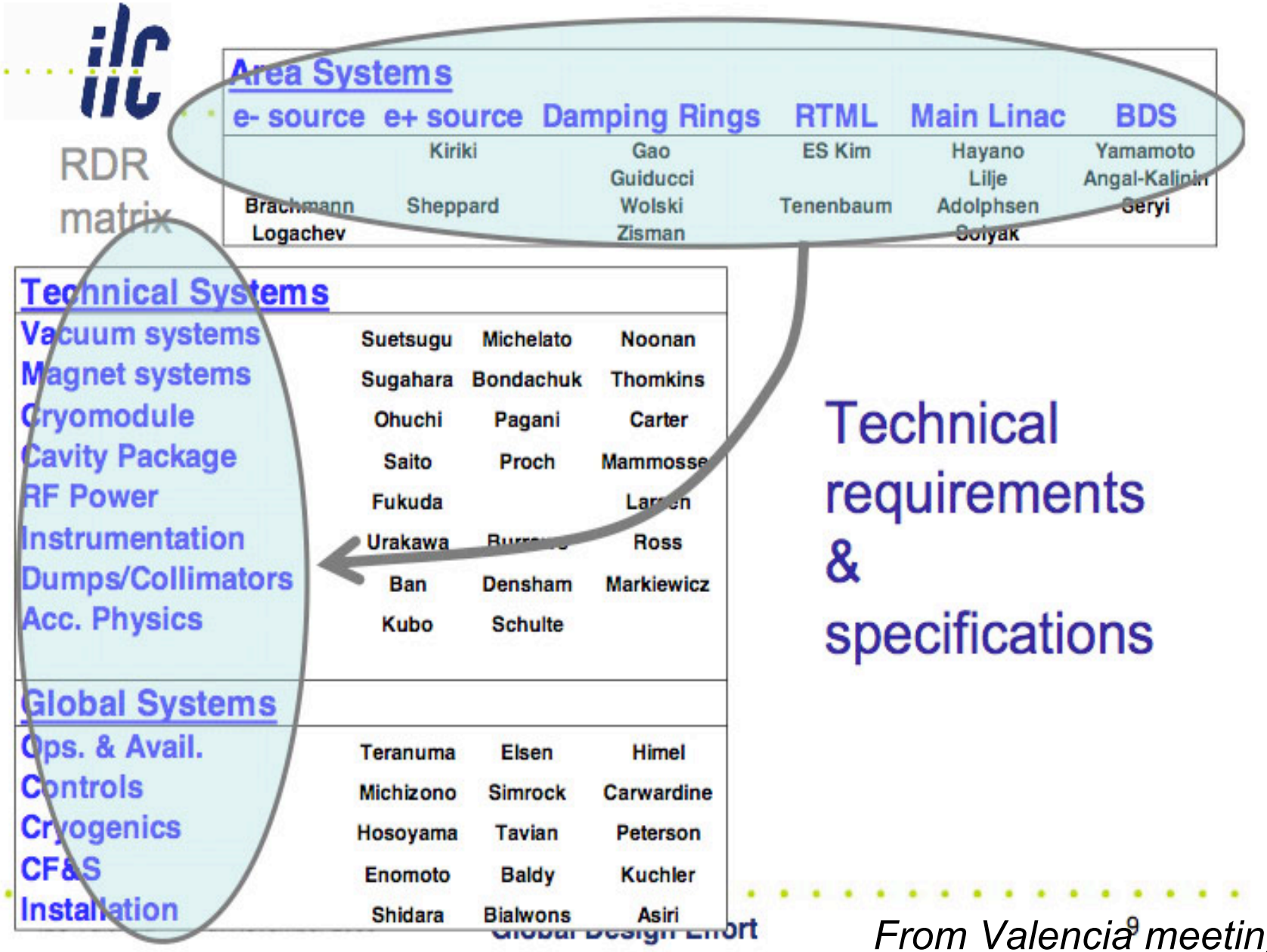
Outline

- RDR status
- Cost Management Group
- Traceability
- Cost reduction strategies, examples
- TDR Planning

TD Phase challenges & issues

- RDR – Now one year old
  - **Legacy design effort**
  - **CRITICAL: maintain and document traceability of value estimate, bases of estimates, and RDR design**
  - **Every day more is 'forgotten'**
- TD Phase extended to 2012; resources are significantly reduced.
- CRITICAL: demonstrate clear effort to reduce the cost
  - **Begin to identify possible cost reductions**
  - **"Minimal" 200-500 GeV Collider Concept**
- Plan for critical reviews: internally in 2010, publically in 2012

RDR matrix



Area Systems					
e- source	e+ source	Damping Rings	RTML	Main Linac	BDS
	Kiriki	Gao	ES Kim	Hayano	Yamamoto
		Guiducci		Lilje	Angal-Kalinin
Brachmann	Sheppard	Wolski	Tenenbaum	Adolphsen	Geryi
Logachev		Zisman		Solyak	

Technical Systems			
Vacuum systems	Suetsugu	Michelato	Noonan
Magnet systems	Sugahara	Bondachuk	Thomkins
Cryomodule	Ohuchi	Pagani	Carter
Cavity Package	Saito	Proch	Mammosse
RF Power	Fukuda		Larsen
Instrumentation	Urakawa	Burrows	Ross
Dumps/Collimators	Ban	Densham	Markiewicz
Acc. Physics	Kubo	Schulte	

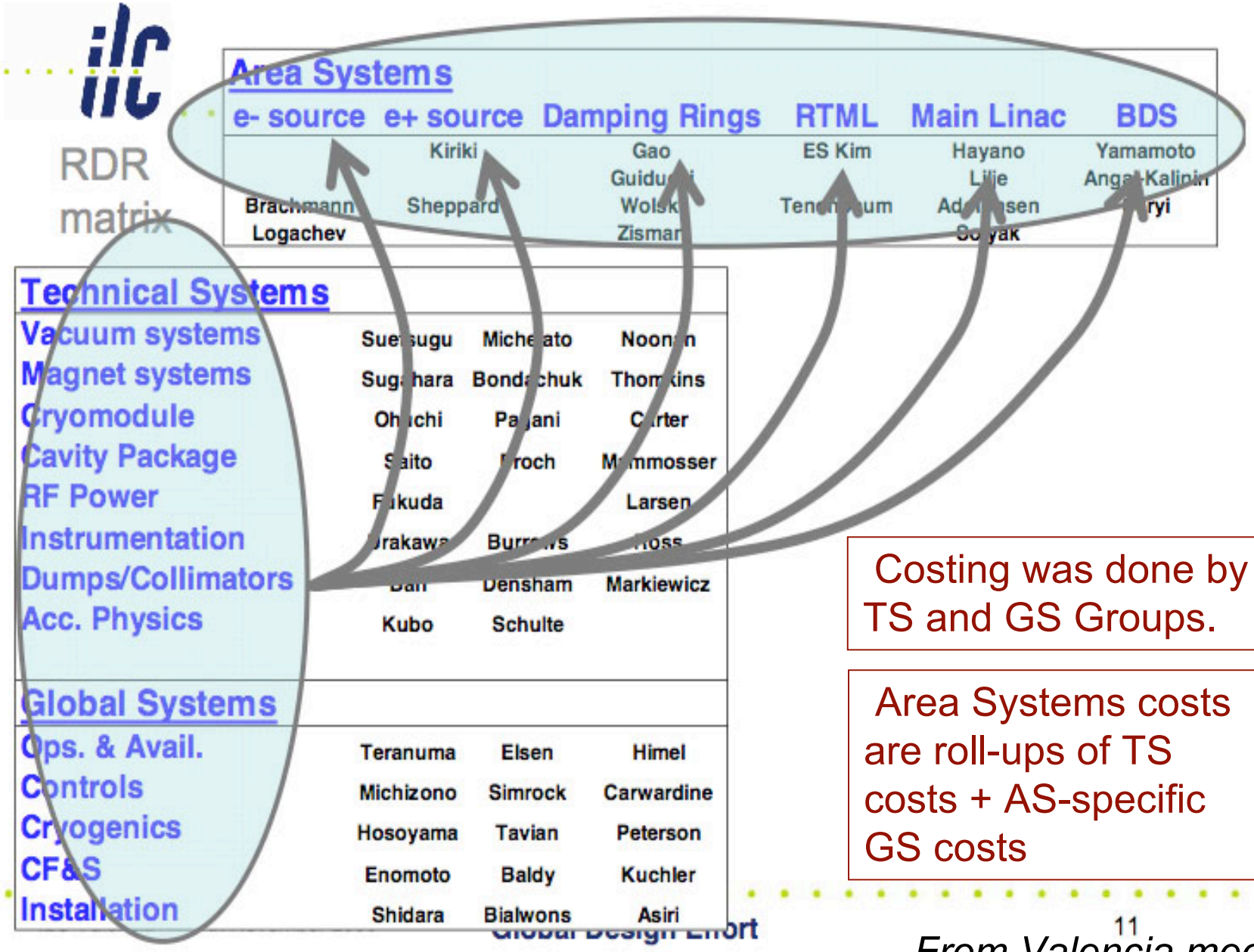
Global Systems			
Ops. & Avail.	Teranuma	Elsen	Himel
Controls	Michizono	Simrock	Carwardine
Cryogenics	Hosoyama	Tavian	Peterson
CF&S	Enomoto	Baldy	Kuchler
Installation	Shidara	Bialwons	Asiri

Technical requirements & specifications

Global Design Effort

From Valencia meeting

RDR matrix



Costing was done by TS and GS Groups.

Area Systems costs are roll-ups of TS costs + AS-specific GS costs

From Valencia meeting

Legacy RDR cost information

- Types of information
  - **Spreadsheets**
  - **Emails**
  - **Presentations**
  - **Electronic documents (word, pdf, etc)**
- Formats
  - **No consistent format for information**
  - **Different levels and types of information**
  - **Data is organized differently**
- Impact
  - **Difficult to roll up data for comparison and analysis**
  - **Difficult to recreate a consistent costing drill-down**

Archeology..

- In detail, what is the design that was costed…?
- What items were costed, how are the costs organized (eg WBS, CBS)…?
- What design criteria were used and where did they come from…?
  - **Internally derived**
  - **External parameters/requirements**
  - **Constraints**
- Is there documentation to support the above?
- Trace the requirements to their source…
  - **Requirements provided, internal best guesses,…**
  - **Conversion from 'requirement' to engineering design**
- Consolidate/generate documentation to show the traceability

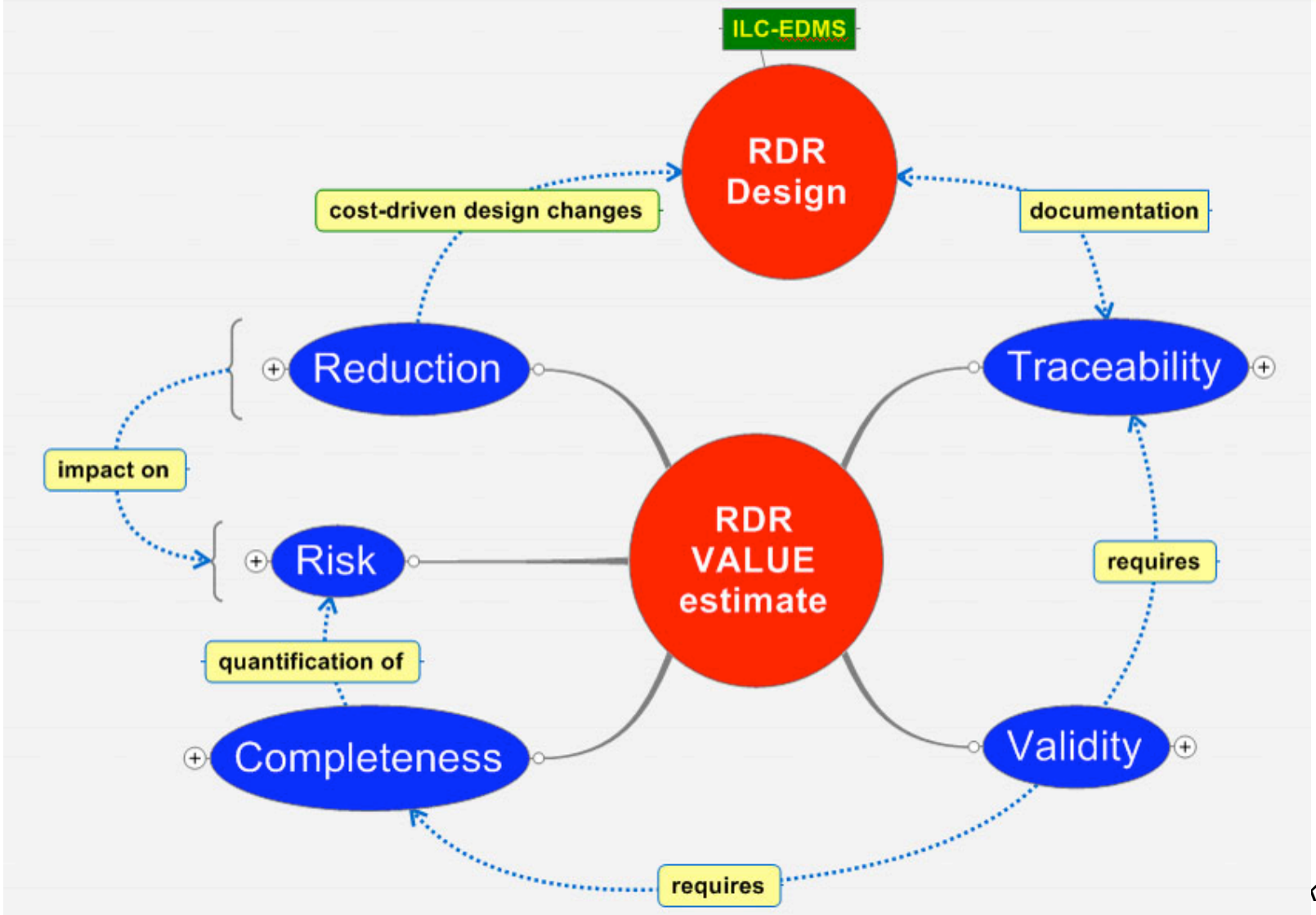
Formation of Cost Management Group

- Re-establish traceability with RDR design requirements, identify missing information (coordinate with technical groups)
- Re-structure and consolidate existing cost information for “better access”

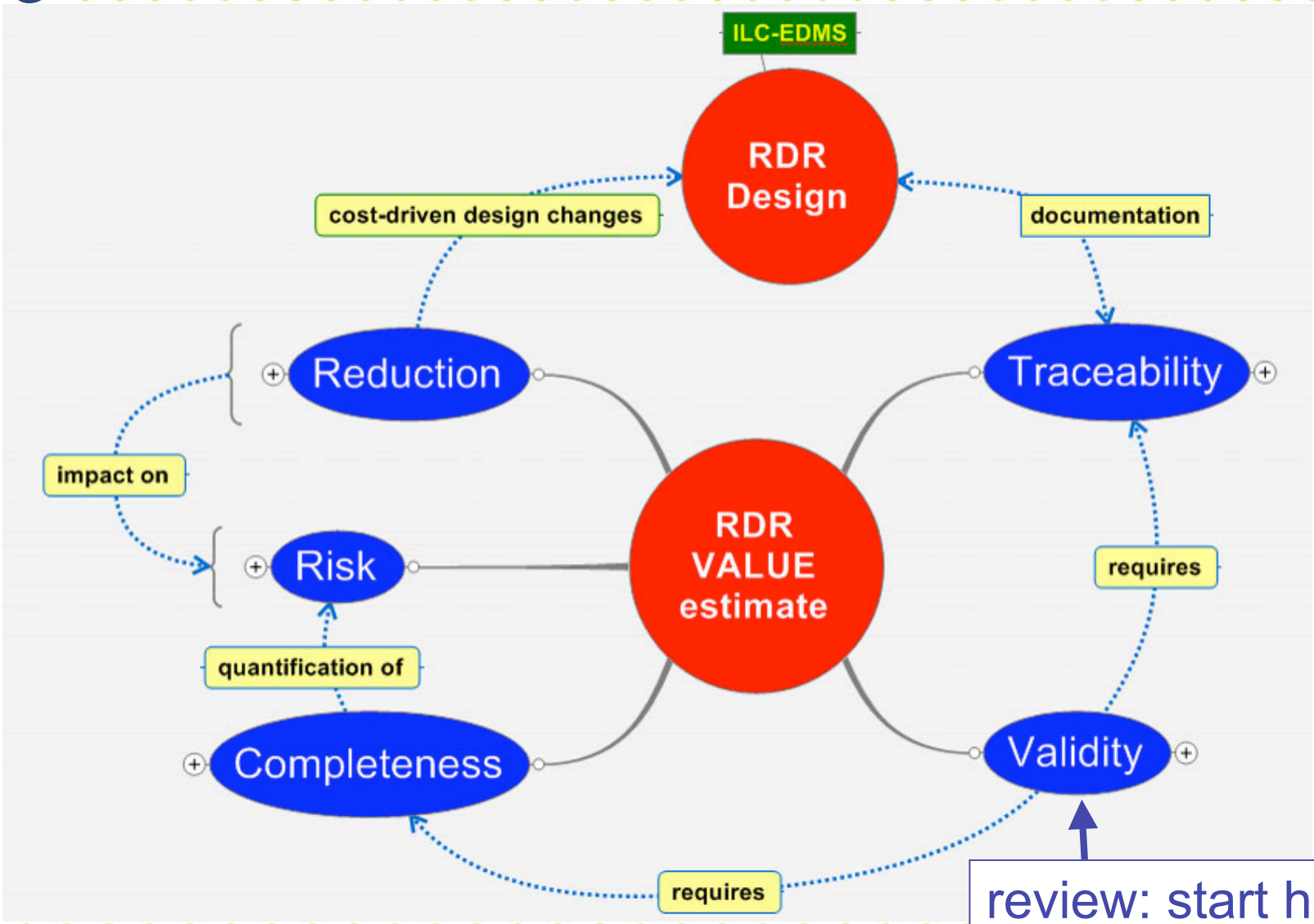
- Examine the cost data for inconsistencies, discrepancies, questionable entries, missing information
- Develop cost-reduction design scenarios
- Push-back on the design (cost awareness)

- Prepare for critical design and cost reviews (2010, 2012)

Defining our (CMG) Goals

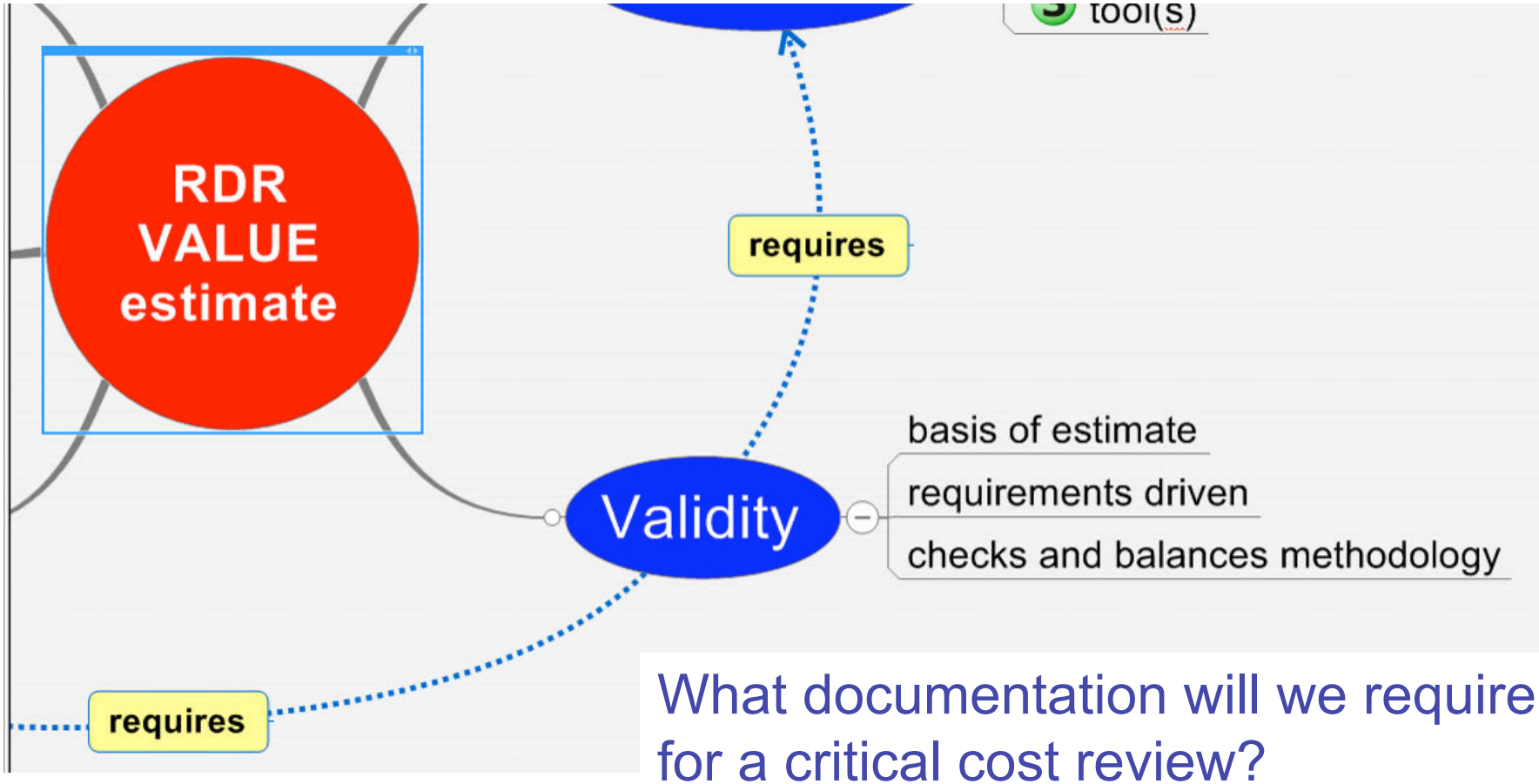


Defining our (CMG) Goals



N. Walker

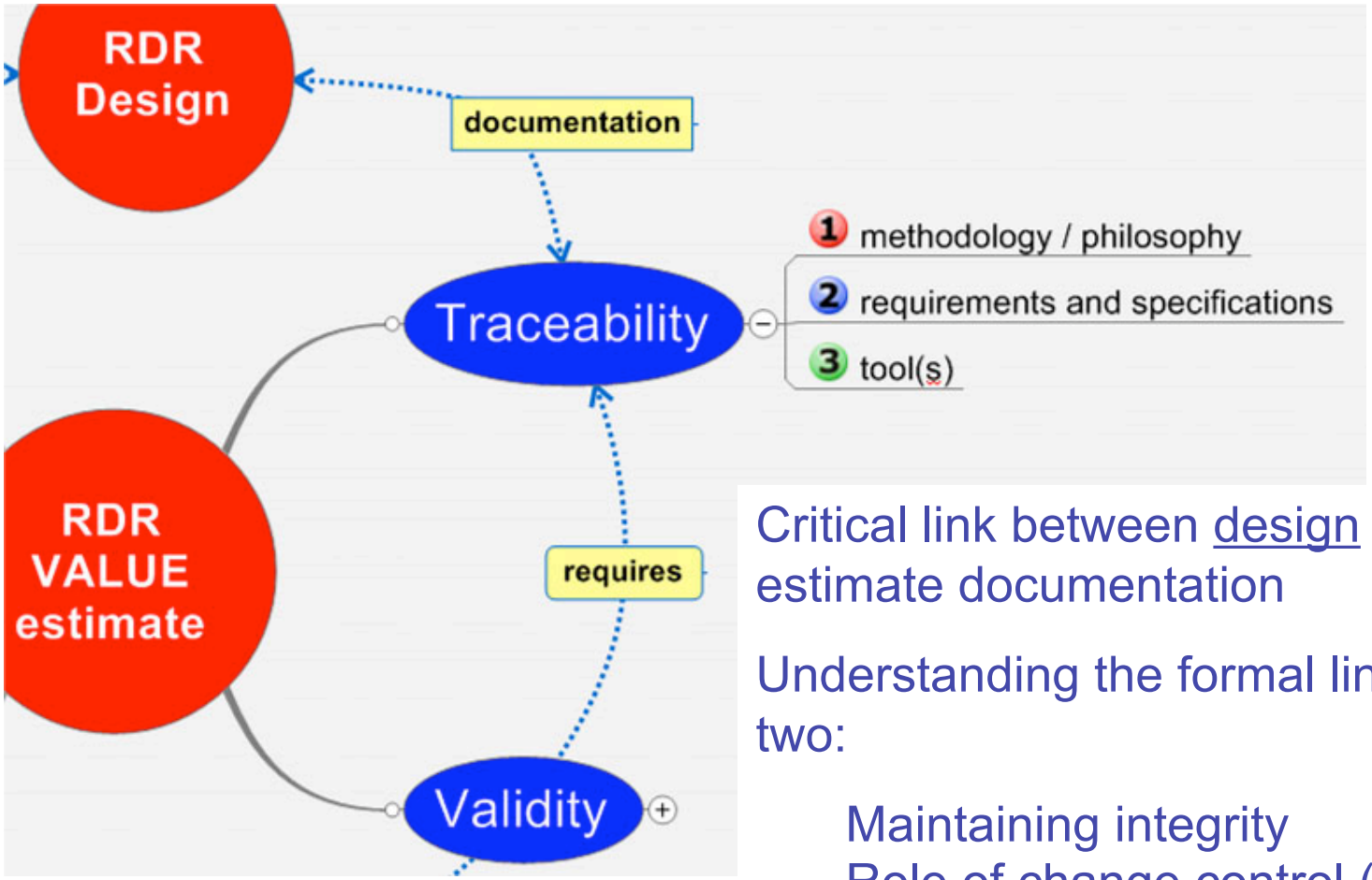
Elements: VALIDITY



What documentation will we require for a critical cost review?

How do we intend to present it?

Elements: TRACEABILITY

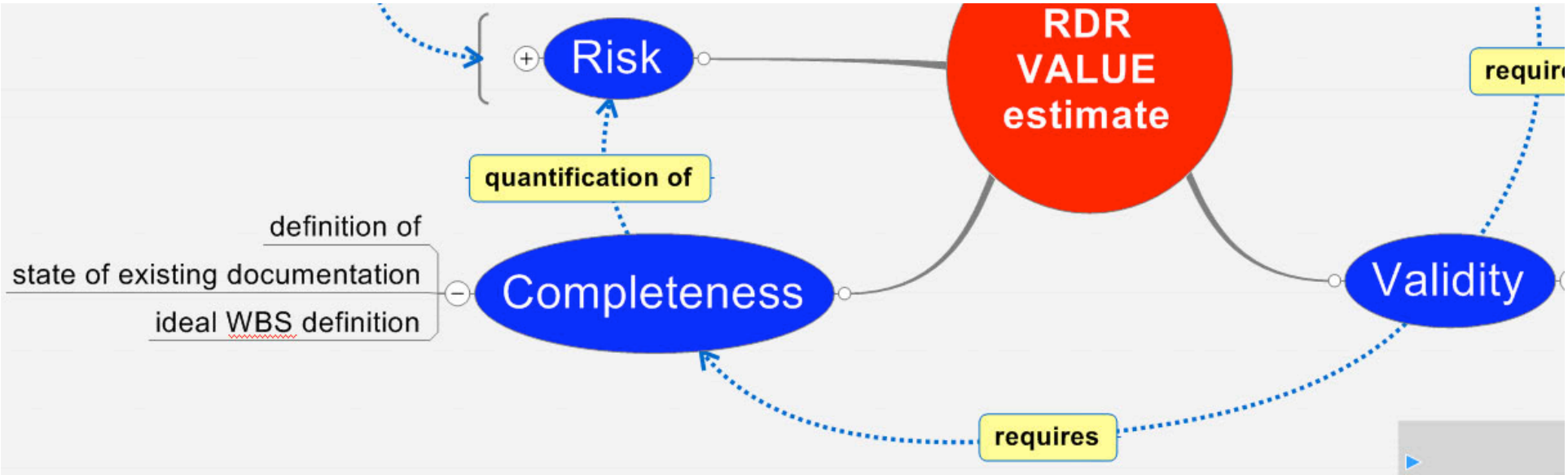


Critical link between design and cost-estimate documentation

Understanding the formal link between the two:

- Maintaining integrity
- Role of change control (→ Toge)
- Initial configuration (consolidating RDR)

Elements: COMPLETENESS



Definition of (i.e. level of detail) must be defined up-front

- Use RDR value estimate as a guideline (e.g. 1% level)

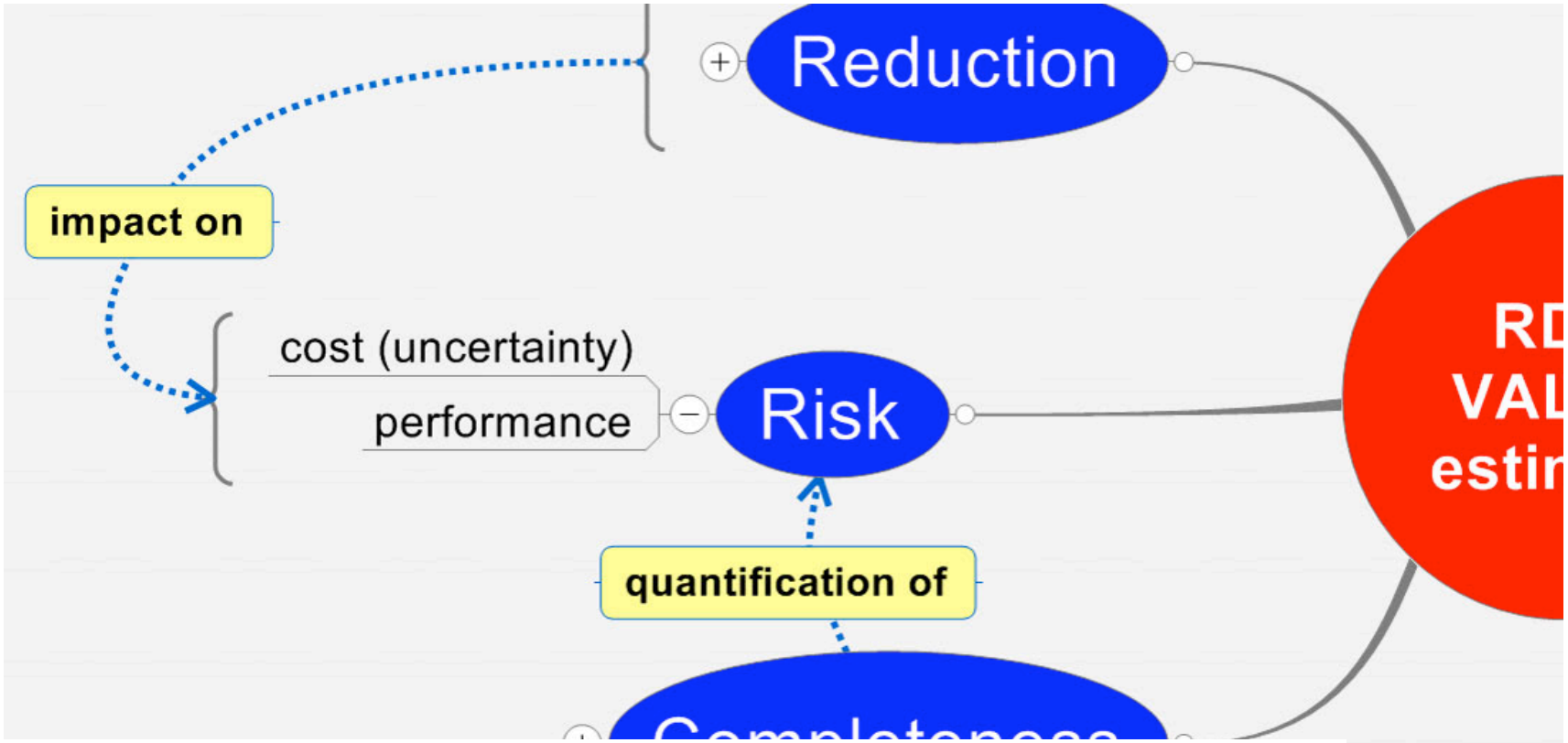
Build ‘ideal’ CBS structure (based on above)

Understand how current information maps to ideal structure

- Where is information missing
- What to do with too-detailed information

N. Walker

Elements: RISK

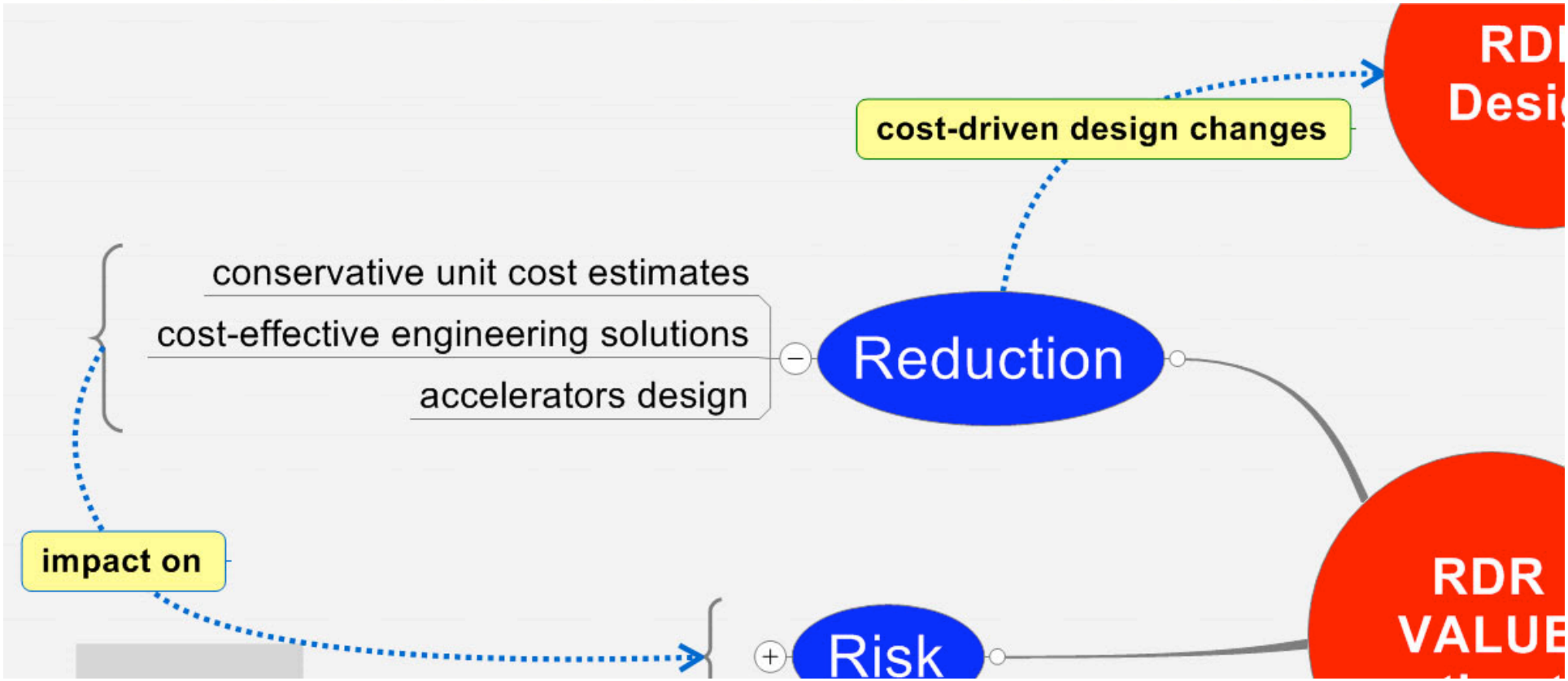


Maintaining a risk register

Understanding (quantifying) value uncertainty

Formally integrating methodology into scheme (tools)

Cost Reduction



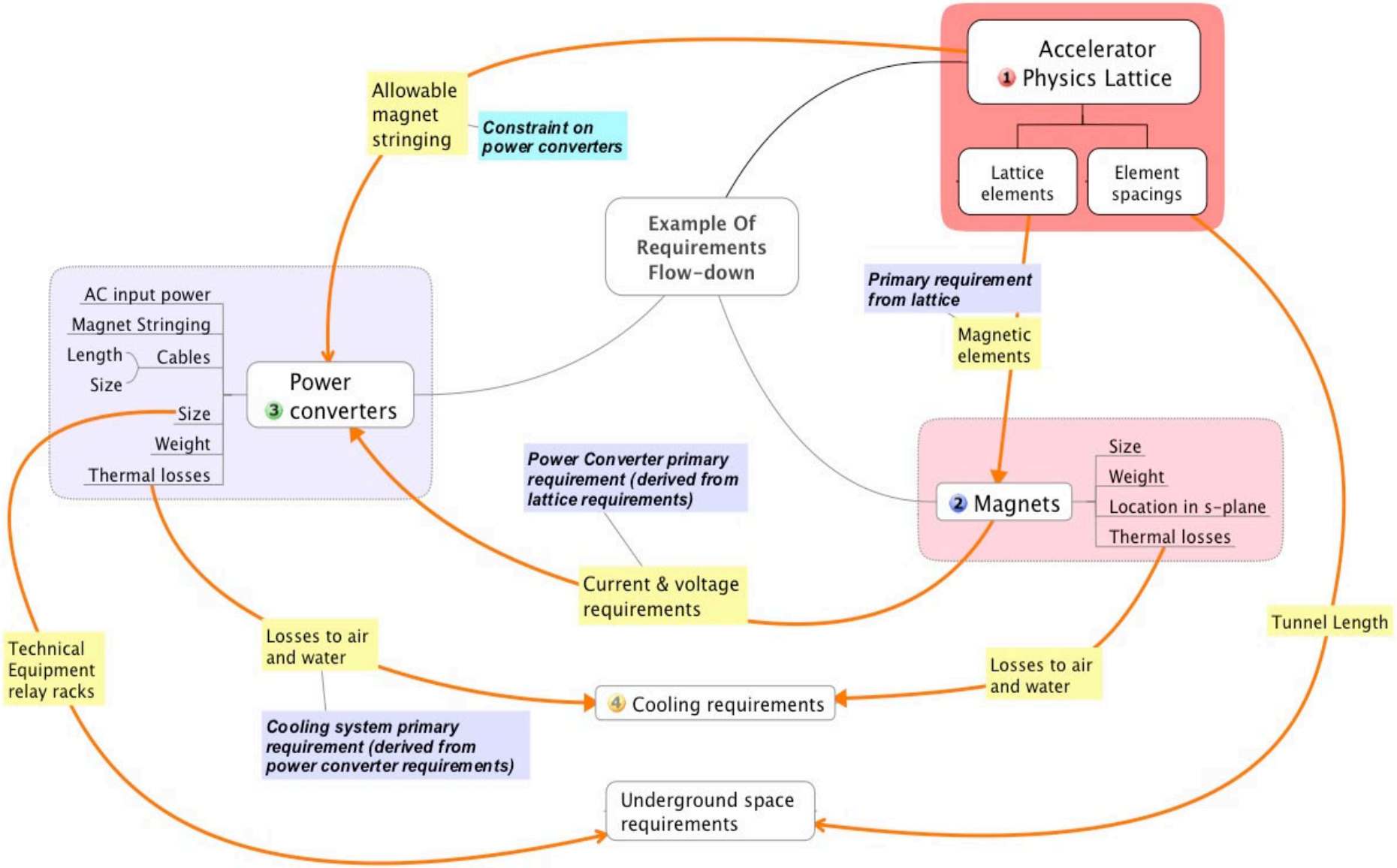
"First step to containing / reducing cost is to keep good track of the existing ones" – *anon*.

N. Walker

First CMG meeting (5-8 May)

- Begin to review details of RDR cost estimate
  - **Accelerator Areas: Positron Source**
  - **Technical Systems: Magnet Systems, HLRF**
  - **Conventional facilities: cooling, underground volume**
- System-level design and cost optimizations
  - **Eg, do detailed requirements make sense: impact of push-back**
- TDR Planning: how to manage costing information during TDR
- Begin to develop cost reduction strategies, review examples
  - **Technical systems, conventional facilities**
  - **Staging: implement full machine performance incrementally**
  - **Possible cost-favorable accelerator design changes**

How well can we trace requirements…?



Idealized Requirements model (Technical System "world view")

- Inputs to the Technical System (TS)
  - **Primary requirements of the TS**
  - **Constraints on the TS**
  - **Dependencies**

Requirements from other groups
Decided / guessed by TS Group
Implicitly assumed by TS Group

- Internal
  - **Engineering requirements derived from external requirements & constraints**
  - **Internal requirements & constraints**

- Outputs from the Technical System
  - **Derivative requirements to other TSs**
  - **Constraints applied to other systems**

Requirements given to other groups
Implicitly assumed

At 6.7B, the machine is too expensive

We must show clear efforts to re-assess the design and reduce the cost

Where might we find cost reductions?

	Main Linac	DR	RTML	e+ source	BDS	common	EXP Hall	e- source	sum
Convent. Facil.	> 15 %								
Cavities & CM	> 15 %								
RF Power									
Cryogenics									
Magnets & PS									
Controls									
Vacuum									
Instrumentation									
Dumps & Collim									
Installation									
e+ specific									
e- specific									
DR specific									
total									

key:

> 15 %	> 15%
	5-15%
	1-5 %
	0.5-1%
	0.1-0.5%
	< 0.1%
	no entry

Installation is mostly accounted as in-house labor

note ordering as for rainbow

P. Garbincious

Focus on Conventional Facilities

- Significant fraction of overall cost
  - **Tunnels, caverns, shafts**
  - **Services: cooling, electrical utilities**

- Assess requirements and costs
  - **Was CFS given "reasonable" requirements…?**
  - **Can we push back, eg cooling delta-T…?**
  - **(Technical groups designed systems to meet the requirements they were given)**

CF breakdown + electrical & cooling loads

Conventional Facilities average over 3 regions	Main Linac	Damping Rings	Rings to ML	Positron Source	BDS & Dumps	Common	Exp Hall	Electron Source	sum
Civil Engineering:									
Outsourced Engineering									
Underground Facilities:									
* Shafts									
* Tunnels									
* Caverns & Exp Hall									
* Crossovers & Penetrations									
Surface Structures									
Site Development									
Electrical									
RF power (MW)	75.7	14.0	7.1	4.1				1.1	102.0
Conventional power (MW)	13.5	1.7	3.8	7.3	4.9			1.2	32.5
Room Temperature Magnets	0.8	7.9	4.7	8.9	2.6			0.7	25.6
Water Systems power (MW)	9.9	0.7	1.3	1.3	3.5			1.3	17.9
Cryogenics power (MW)	33.9	1.8	0.0	0.5	0.3			0.5	36.9
Emergency power (MW)	0.4	0.2	0.2	0.2	0.3			0.1	1.4
Total Power (MW)	134.2	26.3	17.2	22.3	11.7			4.8	216.3
Air Treatment									
Piped Utilities									
Process Cooling Water									
LCW load (MW)	56.0	17.7	9.3	17.5	46.3			2.9	149.6
Chilled Water (MW)	21.1	1.8	1.3	5.3	1.0			1.4	32.0
** Cryo Air Towers (MW)	33.9	1.8	0.0	0.5	0.3			0.5	36.9
Handling Equipment									
Safety Equipment									
Survey & Alignment									
sum									

* scaling underground facilities components: UF(i,j) = UFavg(i)*UFamericas(i,j)/ΣUFamericas(i,k)
i = ML, DR, RTML, e+ source, BDS, common, Exp Hall, e- source
j = shafts, tunnels, caverns & halls, crossovers & penetrations

** cooling systems are included in cost of cryogenics plants

key: > 5 % | 1-5 % | 0.5-1 % | 0.1-0.5 % | < 0.1 %

P. Garbincious

Exploring cooling water cost reductions

Main Linac Water Cooling

Strategy –

RDR criteria tables; RDR design and estimate are useful input

Detailed design resources very limited

Cost optimum will be developed using parametric approach

Technical

Must reject 'commercial off-the-shelf' specifications where/if cost effective

Process

Who and how

Data – provided by CFS (Emil and DESY/XFEL)

Plans

CMG DESY 05 May 2008 M. Ross
ILC - GDE

Cost reduction proposals

- *Increase delta T*
- *Increase tunnel air temperature*
- *Several design changes*

Needed to better assess

- *Impact on technical systems*
- *More thorough evaluation of technical design and costs*

Scaling of Process Water Costs (cont'd)

- Cost Reduction Example
  - Assuming Piping is half of the cost and the
  - Cost Scaling Factor is $\alpha = 0.8$

$$\frac{K'}{K} = \frac{1}{2}\left(\frac{\Delta\vartheta}{\Delta\vartheta'}\right)^{2\alpha/5} + \frac{1}{2}\left(\frac{\Delta\vartheta}{\Delta\vartheta'}\right)^{\alpha}$$

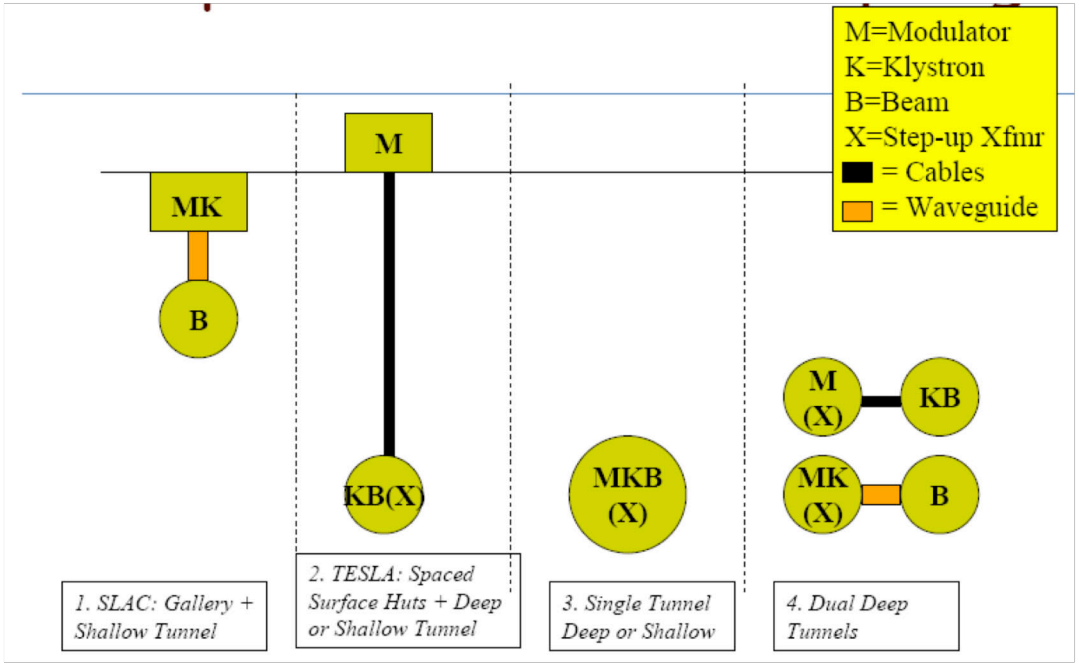
- Then the Cost are reduced to 50 % if the Temperature Rise is increased by a factor of four.

Exploring one vs two tunnels

A subject of much debate during the RDR phase

Tunnel configurations

RDR White Paper explored four options



5 May 08 Tom Himel

Considerations

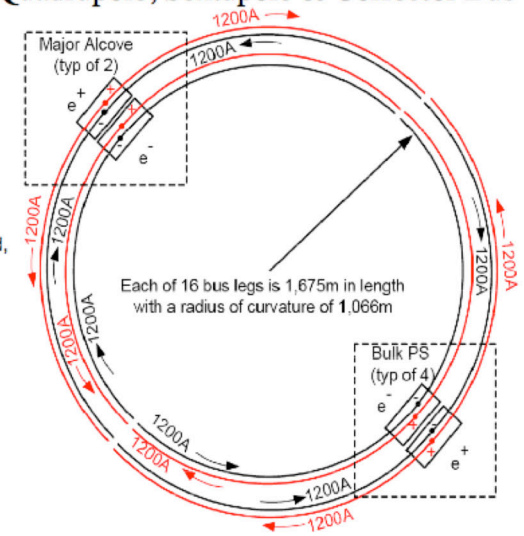
- Cost savings
- Life safety, egress, etc
- Thermal loads
- Equipment access
- Radiation damage
- Machine availability
- Operations model

Exploring magnet systems cost savings

Distributed Power Supply Concept

- 4 bulk supplies
  - **2 in each major alcove**
  - **Feed 8 buses (4 per ring)**
  - **Individual DC-to-DC converters for each magnet**
    - Water-cooled racks distributed around the ring
    - Magnets
      - Quadrupoles
      - Sextupoles
      - Correctors (dipole, skew quad, other)
  - **Distribute AC to local wiggler power supplies**
  - **Reduce heat load around tunnel due to cable losses to air to <50W/m**
- Main dipoles powered in 6 strings per ring
  - **6 dipole supplies per alcove**
- Injection/Extraction lines
  - **Same as for RDR**

Quadrupole, Sextupole & Corrector Bus



Nov. 5, 2007 Damping Rings EDR KOM, Cockcroft Institute 34

Distributed raw DC

- *Magnet cables > 50% of DC magnet systems costs*
- *Distributing raw dc saves 35% of RDR costs*

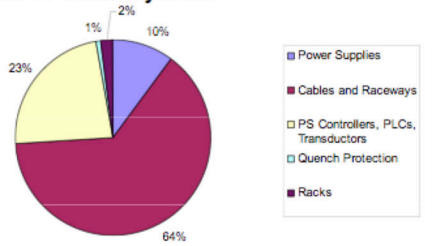
Cost Impact

Cable costs greatly reduced!

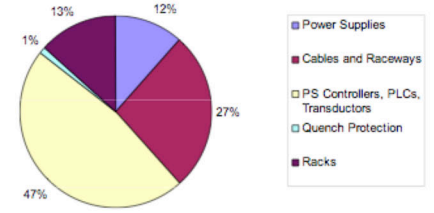
35% cost savings relative to RDR

- Controls-related hardware now dominant cost
  - **Some obvious further work to reduce costs in this area**

RDR Power System



Distributed Power System



Nov. 5, 2007 Damping Rings

Candidate cost reductions

- Increase magnet voltage: reduce cooling requirements
- Distribute raw dc: reduce cable costs
- Remove redundant systems

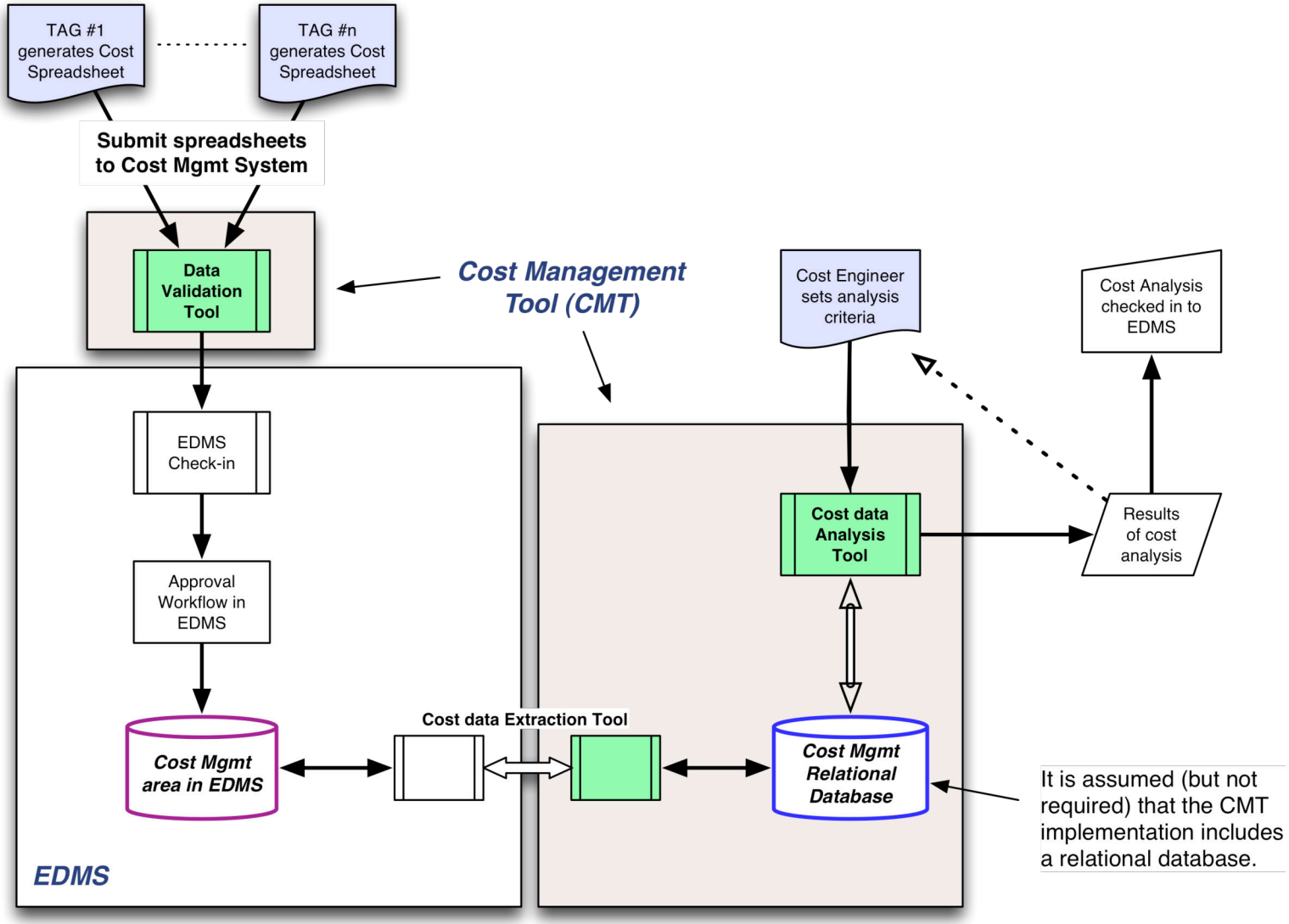
Cost reduction requires collaboration

- Cost Management Group can only go so far…
  - **Develop, rank initial proposals**
  - **Technical Groups do the detailed assessments.**
- Must understand cost derivatives, be able to evaluate different design options, trade studies
- Technical Groups are best placed to develop proposals for cost reduction

Organizing information for the TDR cost estimate

- All costs must be traceable to their source and to a basis of estimate
- All costs must be traceable to the technical design.
- Documentation must be better formalized and more consistent in format and content
- Use spreadsheets for data entry
- Data must be entered in a consistent format that will be defined by PMO.
- Existing RDR cost data
  - **Migrate existing cost data to the new format.**

Model for cost analysis tool



Data analysis ‘use cases’

There are many ways to look at the data

- Generate a cost-report of all Magnets, grouped by magnet type.
- Generate a cost-report of all Magnets, grouped by accelerator area.
- Generate a cost-report of the Damping Ring, grouped by technical system, area sub systems
- Generate a cost-report of all EDIA costs. Show the fraction of total items that does not have EDIA costs
- Escalate costs for inflation, handle exchange rates
- Trade off outside vs in-house labor
- Generate a report showing which engineer costed each item
- …more

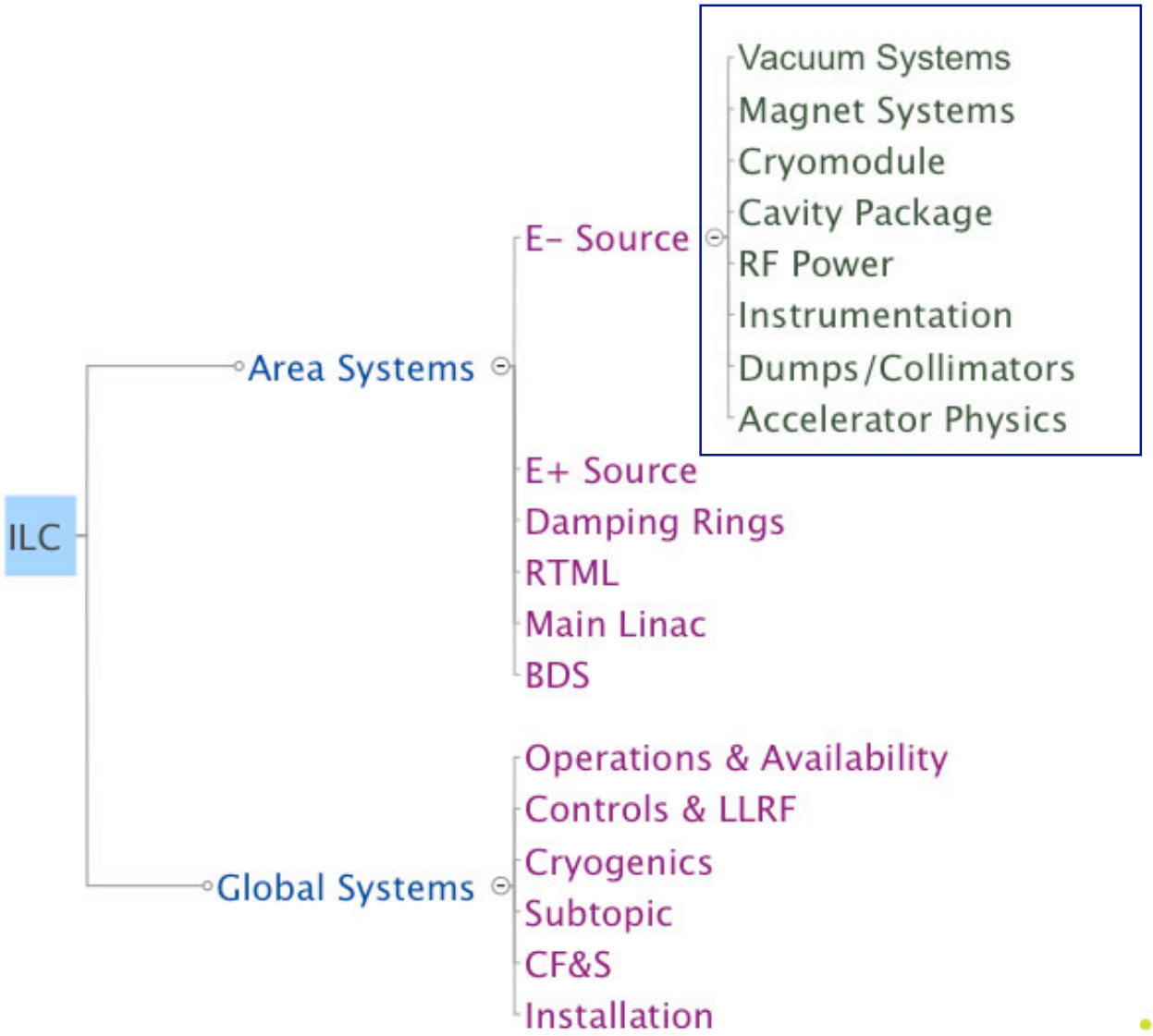
Possible template for cost data

Conceptual Template for Part Record						
Attributes						
	Attribute Name	***Value***				
	Item name (short)	*CM 8C1Q*				
	key = identifier (# or ?)					
	primary tag #0					
	description	*1.3 GHz Cryomodule with 8 cavities and 1 magnet package*				
	cost est in K of currency	*abcd.e*				
	currency	*dollars*				
	unit of estimate	*each*				
	year of est	*2007*				
	confidentiality class 1-5	*3*				
	inflation category	*other*				
	region of estimate	*Europe*				
	estimate provided by:	*Bialowons*				
	institutional labor (hours)	*584*				
	Estimate reference	https://www-ilcdcb.fnal.gov/EDMS/CryooduleEstimate.xls				
	uncertainty shape	*triangular*				
	lower parameter %	*-0.1*				
	upper parameter %	*0.2*				
	uncertainty reference	*Bialowons*				
	date entered	*29-May-08*				
	entered by who	*Garbincius*				
	comments	*includes pro-rated testing facility*				
	Serial_Number	*99345*				
	Part_Tag	*Linac.Cryomodule.Magnet*				
Techical Parameter List						
	Parameter	***Value***	**Units**			
	Length	100	cm			
	Gap	10	cm			
	Nominal Field Strength	0.1	Tesla			
	Nominal Current	100	A			
Parts List						
	Part_Serial_Number	***Part_Short_Name***				
Document List						
	EDMS_Document_ID	***Doc_Description***				

Consistent and sufficient information is critical to allow cost analysis and to cost / design drill-down

Need more formalism for TDR: cost and design, requirements, cost information, bases of estimates, documentation

Implied RDR Parts Breakdown Structure from RDR Phase



Technical Systems

Which "…Breakdown Structure" for TDR Phase?

- Work Breakdown Structure
- Parts Breakdown Structure
- Cost Breakdown Structure

- Must have consistency across the limbs in order to do analysis.

- How many elements…?
  - **Difficult to manage more than a few 100…**

Summary

- The RDR design is sound
- Must not lose “corporate memory” of RDR design, cost estimates, bases of estimates.
- Plan for critical technical and cost reviews
- Must reduce the cost of the machine
- Cost Management Group will steward the process …strong collaboration with Technical Groups