EUROν Special Topics

Costing and Safety

Outline

- Costing workshop summary
  - Workshop's aims
  - Highlights from the presentations (my selection!)
  - Costing Roadmap
- Safety
  - What it means and how to deal with it – next steps

Ilias Efthymiopoulos – CERN

(1st) EURONU Costing Workshop - Aims

The cost evaluation of the proposed facilities is part of the design study.

This two days workshop would introduce the cost management techniques to the EURONu participants towards defining a strategy for what needs to be done within the design study.

The workshop will be more of a tutorial and open discussion basis, where the experience from past and present/future HEP accelerator projects will be presented along with methods, techniques and tools used in cost evaluation of big projects.

Workshop program

- http://indico.cern.ch/event/EuroNuCostingMar2010

Monday, 15 March 2010

10:00	[0] Introduction - Cost exercise in EURONu : what should be done? by Ilias EFTHYMIOPOULOS (CERN) (BE Auditorium Meyrin: 10:00 - 10:30)	slides
11:00	✔ [1] Project cost management - what is all about? by Prof. Pierre BONNAL (Business Administration Dept. - HES Geneve, CERN) (BE Auditorium Meyrin: 10:30 - 11:30)	slides
	✔ [19] Experience with the preliminary cost estimate of the LP-SPL by Roland GAROBY (CERN) (BE Auditorium Meyrin: 11:30 - 12:00)	slides
12:00	[3] Discussion (BE Auditorium Meyrin: 12:00 - 12:30)	

Workshop program

Monday, 15 March 2010		
14:00	[4] Costing in Big HEP Projects - The CLIC case by Philippe LEBRUN (CERN) (BE Auditorium Meyrin: 14:00 - 14:45)	slides
15:00	[5] Cost management plan - error and risk estimates by Prof. Pierre BONNAL (Business Administration Dept. - HES Geneve, CERN) (BE Auditorium Meyrin: 14:45 - 15:30)	slides
	[6] Discussion (BE Auditorium Meyrin: 15:30 - 16:00)	
16:00	tea break (16:00 - 16:30)	
	[7] Cost evaluation for civil engineering and ifrastructure works - the LHC experience by John Andrew OSBORNE (CERN) (BE Auditorium Meyrin: 16:30 - 17:00)	slides
17:00	[8] WP5: Detectors for Neutrinos : cost structure and cost driving elements by Dr. Paul SOLER (University of Glasgow) (BE Auditorium Meyrin: 17:00 - 17:45)	slides
18:00	[9] Day summary (BE Auditorium Meyrin: 17:45 - 18:30)	

Workshop program

Tuesday, 16 March 2010		
09:00	[11] CERN tool for project costing by Jurgen DE JONGHE (CERN) (32-1-A24: 09:00 - 09:30)	slides
10:00	[12] Costing exercize for IDS-NF - a first example by Prof. Kenneth LONG (Imperial College London) (32-1-A24: 09:30 - 10:15)	slides
	coffee break (10:15 - 10:45)	
11:00	[13] WP3 : Neutrino Factory - cost structure and cost driving elements by Juergen POZIMSKI (Imperial College London) (32-1-A24: 10:45 - 11:30)	slides
12:00	[17] WP4: Beta beam - cost structure and cost driving elements by Elena WILDNER (CERN) (32-1-A24: 11:30 - 12:15)	slides
	[14] Discussion (32-1-A24: 12:15 - 12:30)	

Workshop program

Tuesday, 16 March 2010

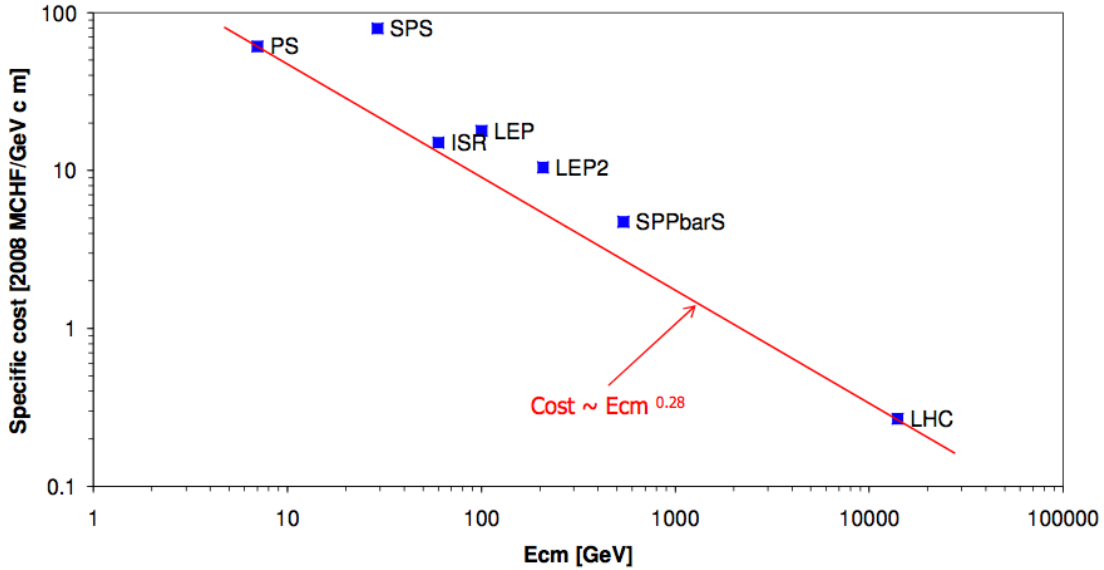
14:00	[15] CNGS project cost management - lessons learned by Konrad ELSENER (CERN) (32-1-A24: 14:00 - 14:30)	slides
	[16] WP2: Super Beams - cost structure and cost driving elements by Marco ZITO (Dapnia/SPP CEA-Saclay) (32-1-A24: 14:30 - 15:15)	slides
15:00	Tea break (15:15 - 15:45)	
	[10] Cost evaluation for Neutrino Factory DS-2 - lessons learned and how to do better? by Michael ZISMAN (Lawrence Berkeley National Laboratory) (32-1-A24: 15:45 - 16:15)	slides
16:00	[18] Wrap-up discussion - actions & next steps by Ilias EFTHYMIOPOULOS (CERN) (32-1-A24: 16:15 - 17:30)	slides
17:00		

- Very interesting presentations – the ones marked worth going through
- Good attendance (~25 people) and lively discussions…

Highlights – Ph.Lebrun *"Costing in big HEP projects –the CLIC case"*

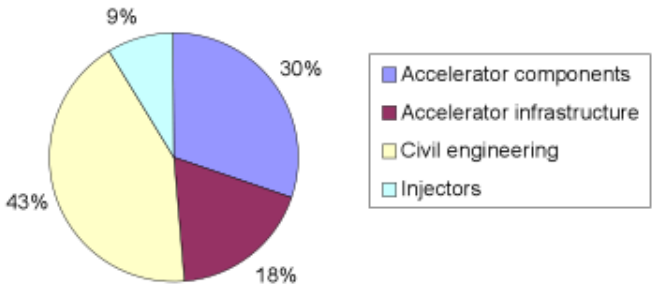
A sustained decrease in specific cost

Specific cost vs center-of-mass energy of CERN accelerators

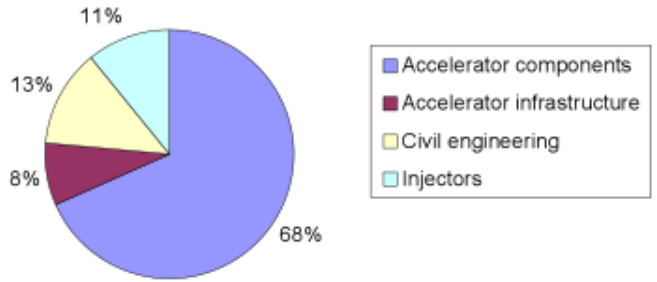


Ph. Lebrun – EURONu Workshop

LEP

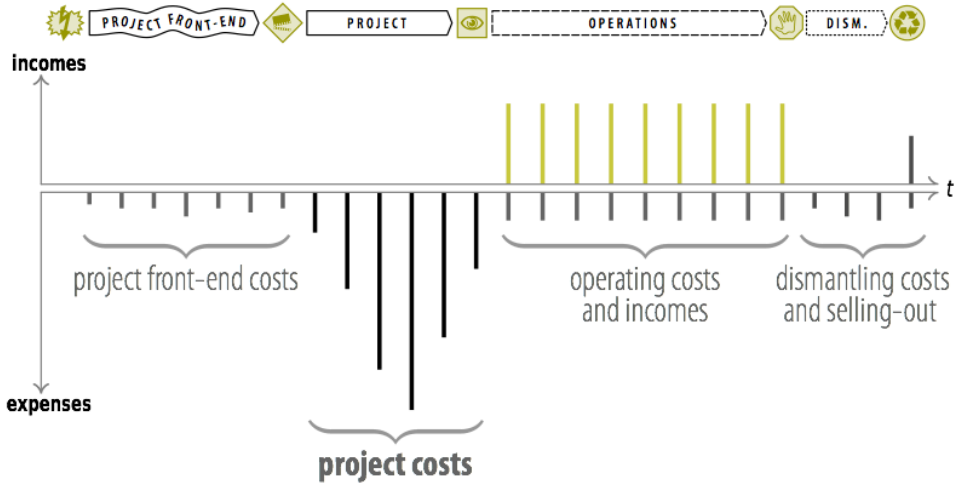


LHC



Highlights – P. Bonnal "Project Cost Management – what is all about?"

Cost Estimating
Which costs to consider ?



8

Cost Estimating
How to estimate ?

4 approaches for estimating the costs (expenses & incomes) of a project

intuitive approaches	global approaches	modular approaches	detailed approaches
rules-of-thumb	analogical or top-down	parametric or CER Cost Estimating Relationship	analytical or bottom-up

16

Highlights – P. Bonnal "Project Cost Management – what is all about?"

Cost Estimating
Global approach | Neighbourhood search

- Linear regressions on various sizing parameters.
- So-called **Chilton law** for total cost :

$$\text{Cost} = a\,(\text{Size})^{b} \quad \text{and} \quad \frac{\text{Cost}}{\text{Cost}_{\text{ref}}} = \left(\frac{\text{Size}}{\text{Size}_{\text{ref}}}\right)^{[0.3\cdots 0.7]}$$

  a and b from tables.
- So-called **Freiman principle** :

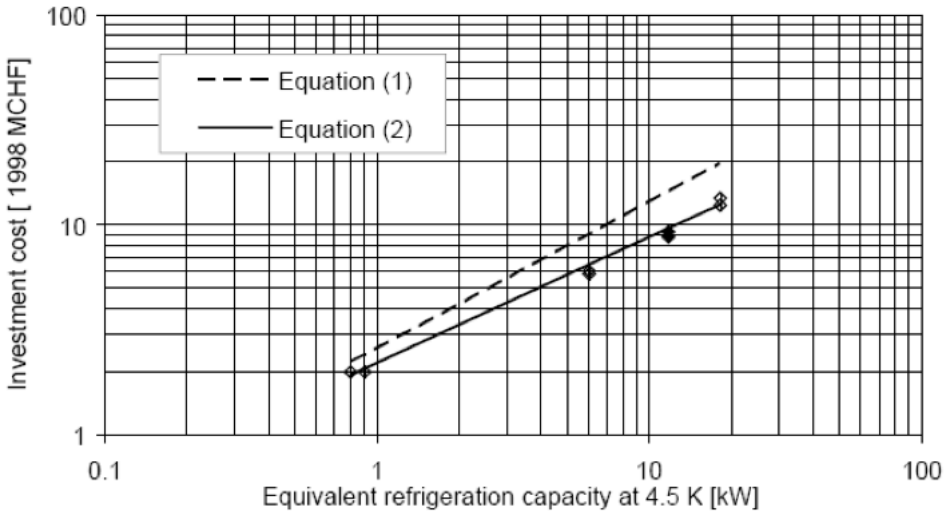
$$\text{Cost} = a\,b^{k}\,(\text{Size})^{1-1/k}$$

  k : a coefficient depicting the complexity of the project ($2 < k < 10$)
  a and b from tables.

- "Distance weighing".

22

Empirical scaling: cost of cryogenic helium refrigerators

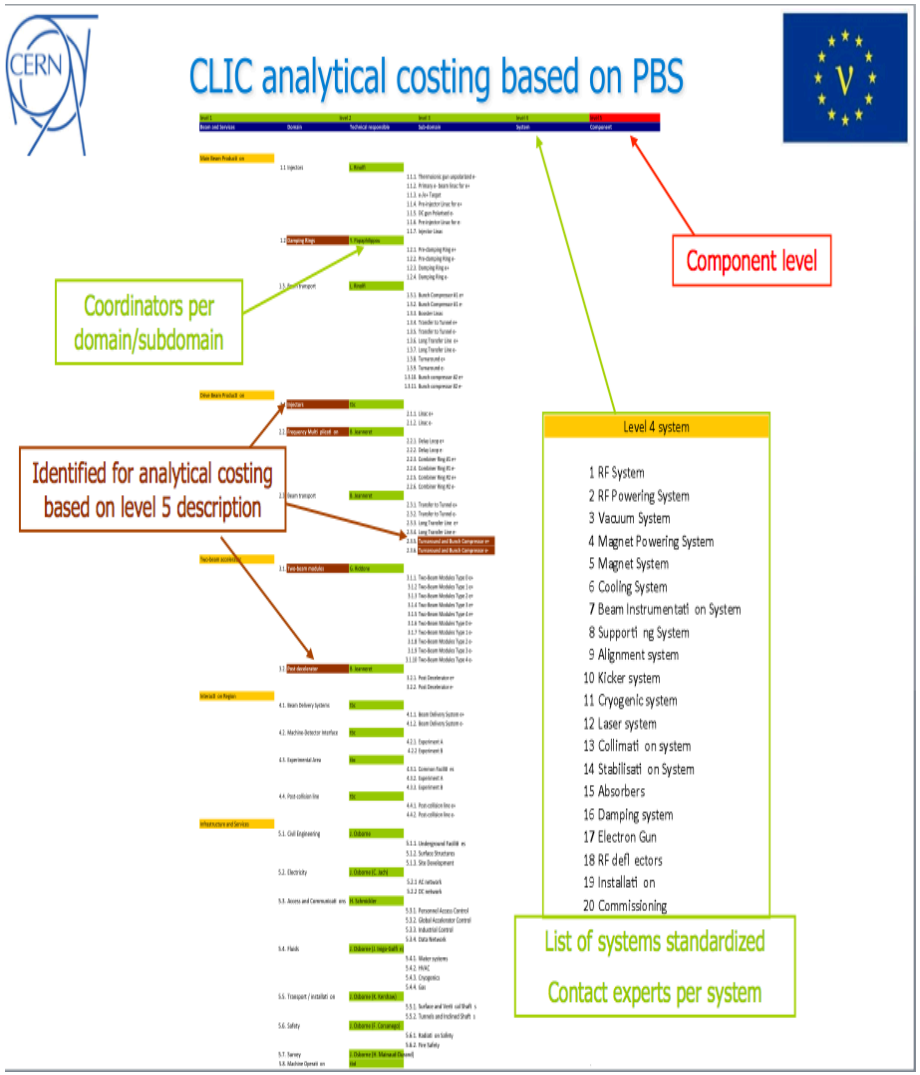


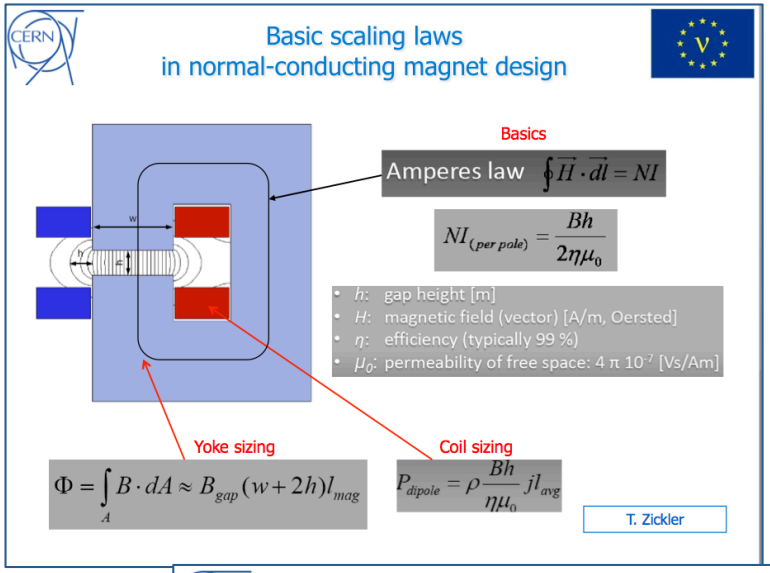
Cost[1998 MCHF] = 2.6 * (Capacity[kW@4.5K])$^{0.7}$ (1)

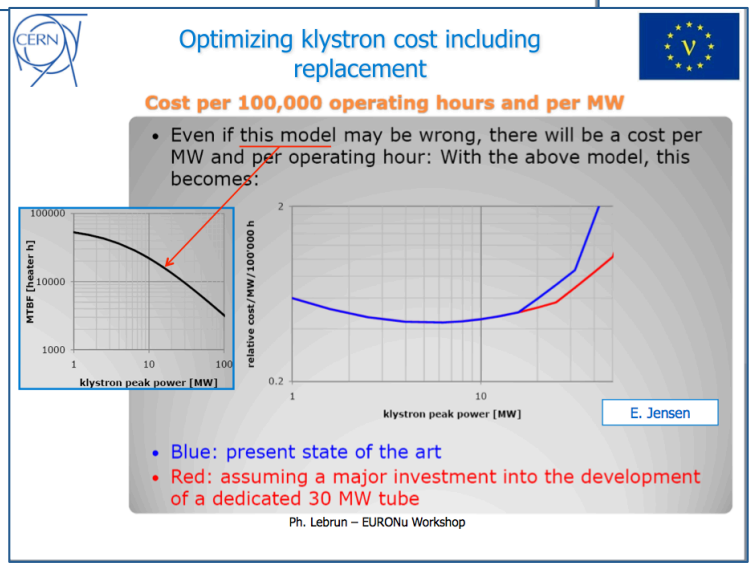
Cost[1998 MCHF] = 2.2 * (Capacity[kW@4.5K])$^{0.6}$ (2)

Ph. Lebrun – EURONu Workshop

Highlights – Ph.Lebrun *"Costing in big HEP projects –the CLIC case"*







Highlights – *Cost optimization*

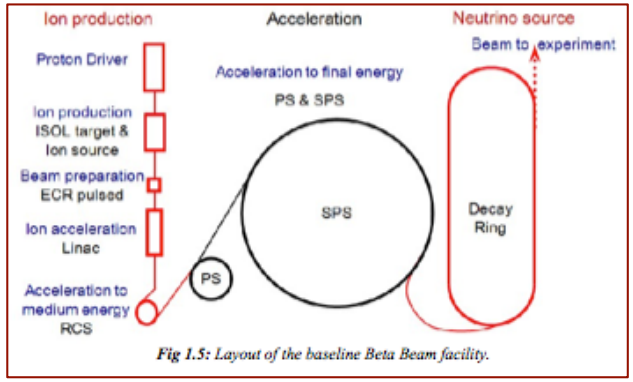


Fig 1.5: Layout of the baseline Beta Beam facility.

Project

Resources/ cost

Performance

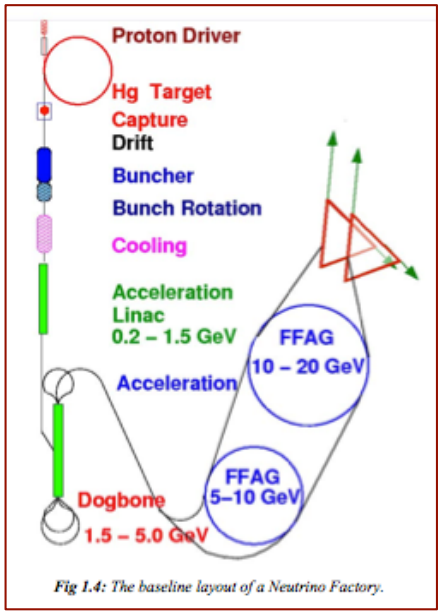


Fig 1.4: The baseline layout of a Neutrino Factory.

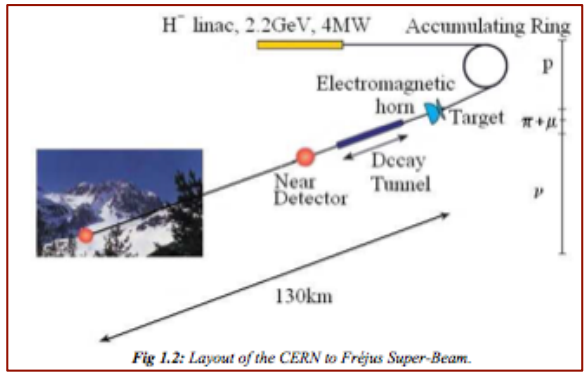


Fig 1.2: Layout of the CERN to Fréjus Super-Beam.

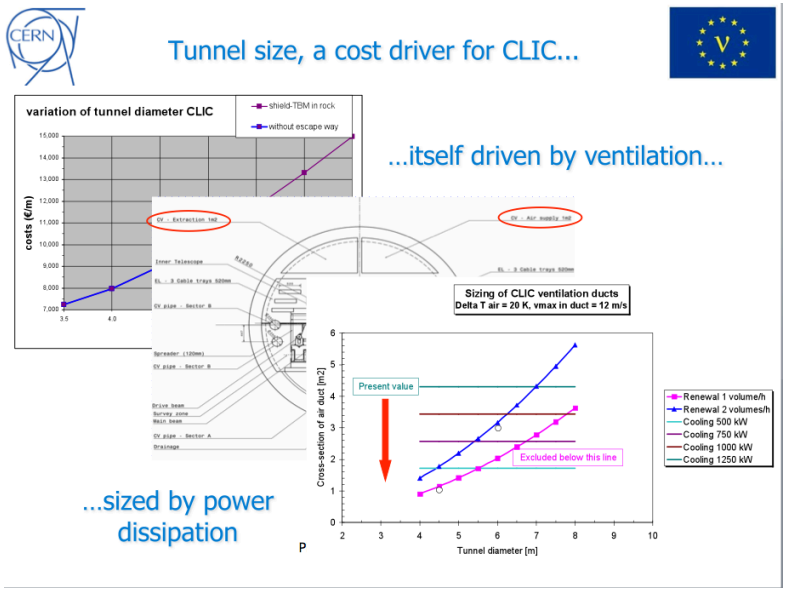
Cost scaling formula for e circular colliders

$$C = k_1\ 2\pi\ \rho + k_2(P_b + P_d) + k_3\ L_c + k_4\ Y\ H(P_b + P_d)/\varepsilon + k_5\ Y\ H(P_b + P_d) + k_6$$

Can we imagine a similar “cost optimization formula” for a Neutrino Factory?

Highlights – *Cost optimization*

- Need to define cost optimization cycles, and continuous follow-up as the design progresses…



Feedback to technical design:
some cost drivers & potential saving options for CLIC

Cost driver	Cost saving impact	Cost mitigation option	Alternative	Risk/benefit of alternative	Specific actions
Accelerating structure stacked disc construction	H		Quadrant construction	Technical validation pending	Industrial cost studies, prototyping
Accelerating structure vacuum tank	M		Sealed construction	Leakage	Prototyping
Production yield of accelerating structures	M to H	Production control and testing			Industrial prototyping & preseries production
Replacement of 80 MV /m accelerating structures	M		Reinstall and reuse 80 MV/m structures	Maximum energy	
PETS on-off mechanism	M	Develop and industrialize			
Drive beam quadrupoles: unprecedented number	M	Automated manufacturing	Customization to position in decelerator	Allows series powering To be developed	Specification from beam physics, industrial study
Powering of drive beam quadrupoles	M	Novel powering scheme ("intelligent bus")	Series powering (plus trim windings?)	Reduce cabling, limit power consumption	Specification from beam physics
Reliability of power converters	M		Hot spares	Improved availability of CLIC	Specification from beam physics

Cost impact
L Order of 10 MCHF
M Order of 100 MCHF
H Order of 1 BCHF

Highlights – *Cost estimate and variance*

Cost variance factors

Decreasing control of project responsible

- Technical design
  - Evolution of system configuration
  - Maturity of component design
  - Technology breakthroughs
  - Variation of applicable regulations
- Industrial execution
  - Qualification & experience of vendors
  - State of completion of R&D, of industrialization
  - Series production, automation & learning curve
  - Rejection rate of production process
- Structure of market
  - Mono/oligopoly
  - Mono/oligopsone
- Commercial strategy of vendor
  - Market penetration
  - Competing productions
- Inflation and escalation
  - Raw materials
  - Industrial prices
- International procurement
  - Exchange rates
  - Taxes, custom duties

Technical definition

Engineering judgement of responsible

Contract adjudication

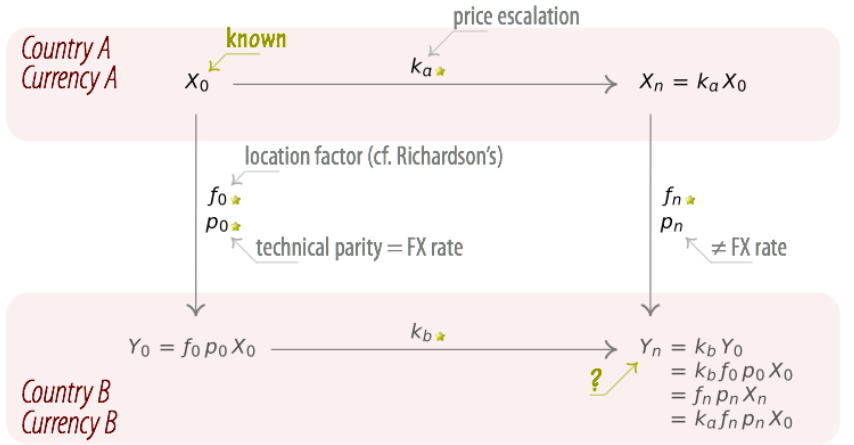
Procurement

Reflected in scatter of offers received from vendors (LHC experience)

Tracked and compensated

Outside project control

Cost Estimating



29

Highlights – P. Bonnal "Project Cost Management Plan – error and risk estimates "

« *Best PM Practices* »

Project cost estimate must include :

- Resulting figure (incl. cost breakdown structure, schedule)
- Approach used (global, modular, detailed) ⇢ Accuracy
- Assumptions (incl. sourcing of economical rates and indices)
- Risks (threaths and opportunities) ⇢ ***Project Risk Register***.

Cost figures must be :

- Sourced (historical data, price inquiry…)
- Localised (location cost factor, FX rate…)
- Discounted (date stamped as if all items were bought now)
- Converted and hence given in the « Project Currency ».

Any project cost estimate should go with a risk register !

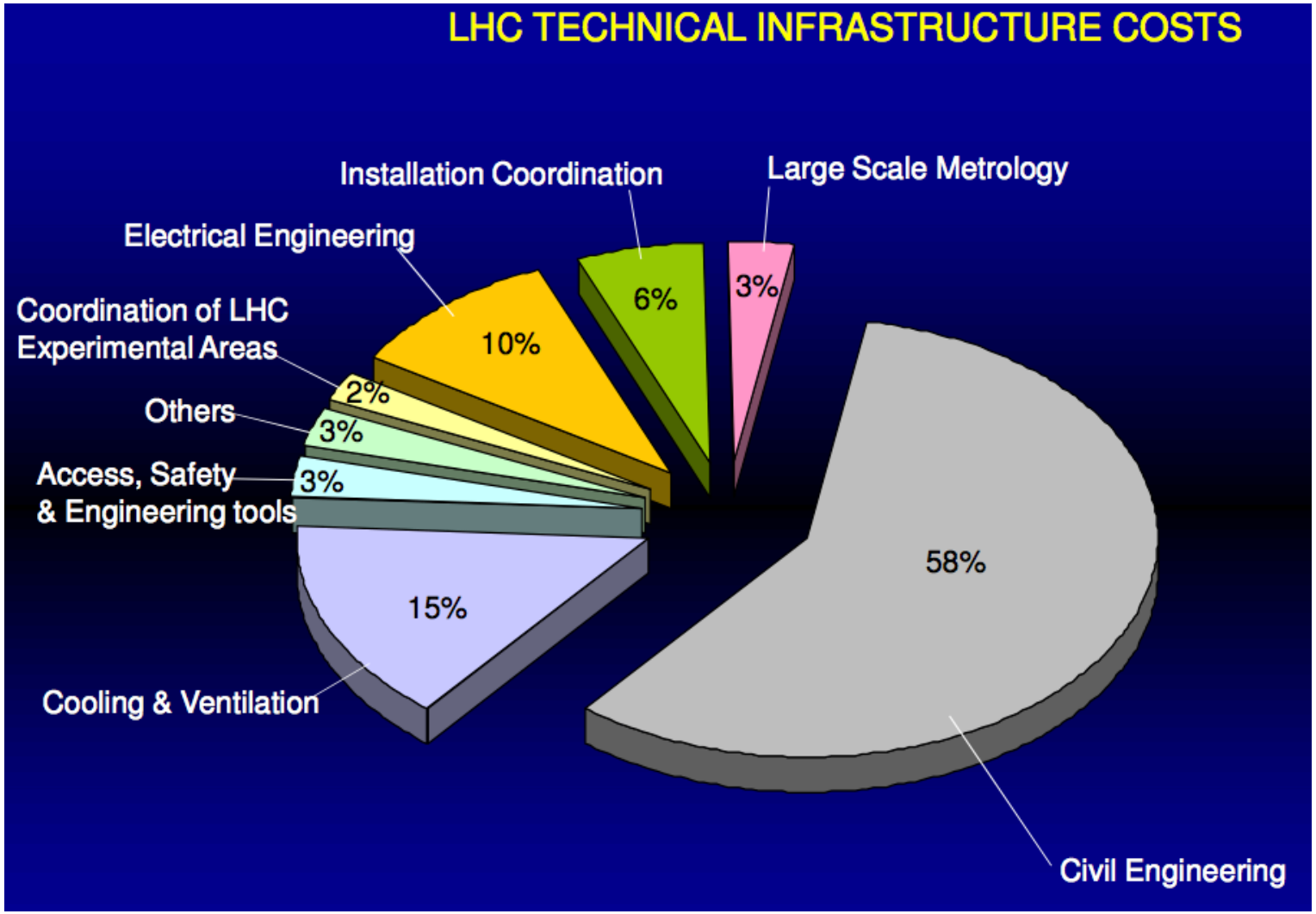
$$S = P \times C$$

P \ C	.05	.1	.2	.4	.8
.9	.05	.09	.18	.36	.72
.7	.04	.07	.14	.28	.56
.5	.03	.05	.10	.20	.40
.3	.02	.03	.06	.12	.24
.1	.01	.01	.02	.04	.08

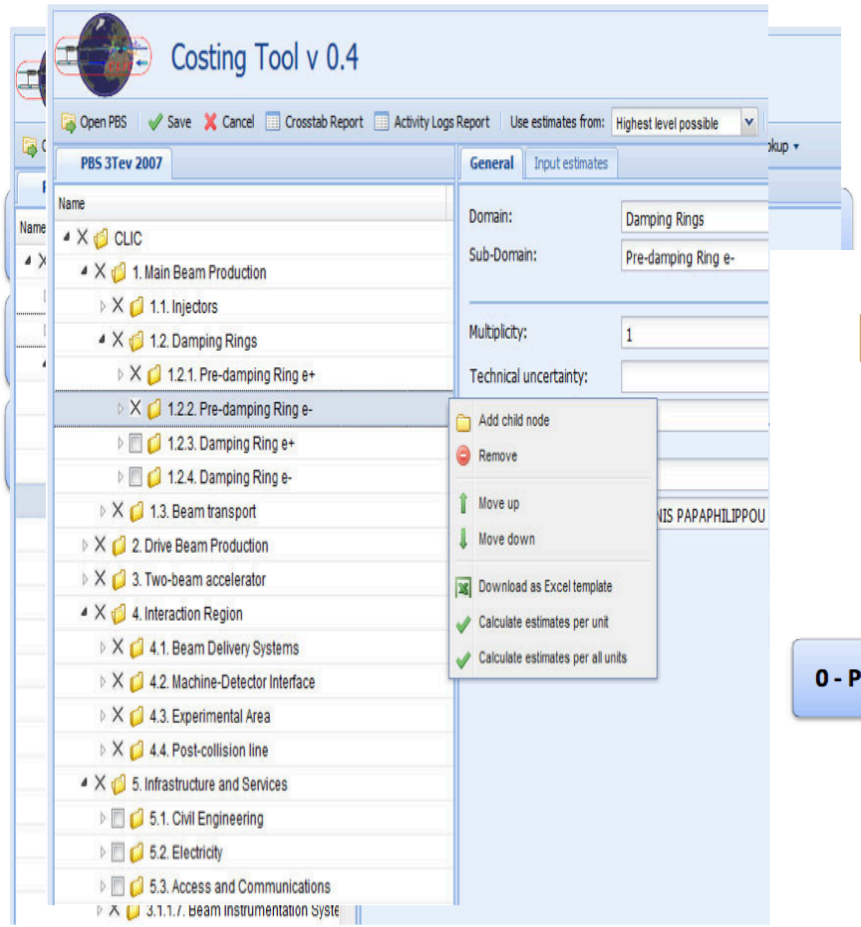
Accept Cancel Mitigate Transfer

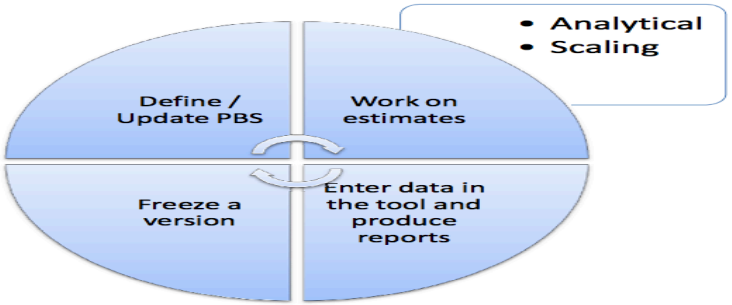
13

Highlights – J Osborne "*Cost evaluation for civil engineering and infrastructure works - the LHC experience*"



Highlights – J. De Jonghe "*CERN tool for project costing*"

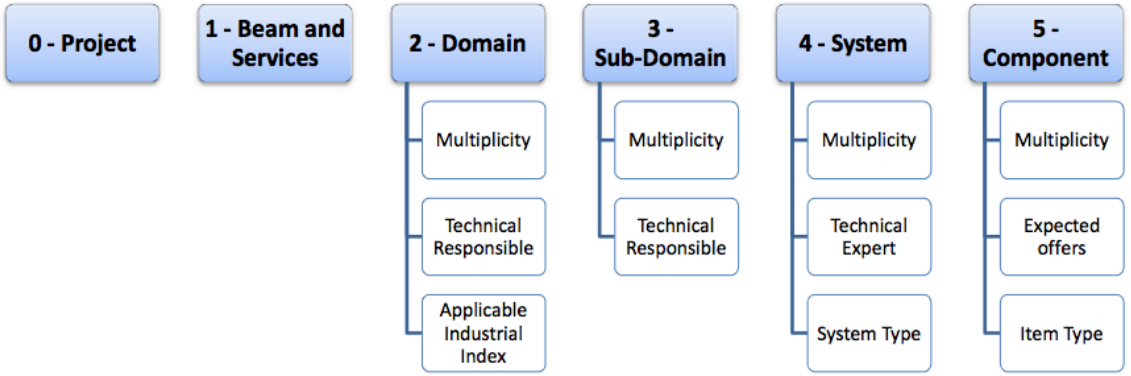




PBS: Tree Structure with 5 levels

Common properties

- Name
- Date of estimate
- Technical uncertainty
- Document link (EDMS, CERN system)



Highlights – K. Elsener *"CNGS project cost management - lessons learned"*

- Contingency
  - CNGS got a few percent of contingency, clearly not enough
- Civil engineering
  - CE drawings were ready in time before tendering -> no change requests, no extra cost
  - CE consultancy services -> very detailed track record of work progress andproblems, 24h every day of CE works -> huge claim by contractor had no chance to succeed
  - Underground Civil Engineering: a (under-)world of its own !
- Infrastructure
  - Industrial standards are not, generally, sufficient for areas with high intensity beams
- Safety matters
- Special and in-kind contributions
  - Follow-up through project lifetime, maintenance once delivered to the final site?

Costing workshop – What we learnt

- The **Work Breakdown Structure (WBS)** of each facility is the key element
  - Should be as complete and accurate as possible
  - Include infrastructure and services (CE ~30% of the total budget)
- Construction cost only or include R&D?
  - Include it in the costing tables but not in the final estimate?
- Would maintenance & operation, **spares** and dismantling costs be included?
  - Yes! – up to some point ….
- Manpower estimates and associated cost?
  - Manpower should be included in FTEs – reporting possibility in real cost
- How to estimate the cost of components before the R&D (and prototyping) is fully completed ?
  - Need to perform risk analysis and impact on cost estimates
- Involve the engineers responsible for the major cost driving elements to assure fast information flow during performance optimization modifications
  - ⇨ Additional resources or ability to approach expertise in particular at CERN would be essential

Costing workshop - Outcome

- CERN has to be the reference site for all: Neutrino Factory, Beta-Beam, Super-Beam

- Using the CERN costing tool is the agreed way to go
  - Profit from the available structure, support
  - Some work is required to customize it to our needs
  - How can we profit from existing knowledge from various projects ???
    - Synergies with CLIC, return experience from LHC, LEP, NF Design studies → create a HEP project cost database?

- Handling of options – the "lego" game
  - Combine options between facilities & detectors & localization
  - Would be possible to define a **Facility optimization formula** for the cost ???
    - **F = f (performance, ν-source, detector, localization)**

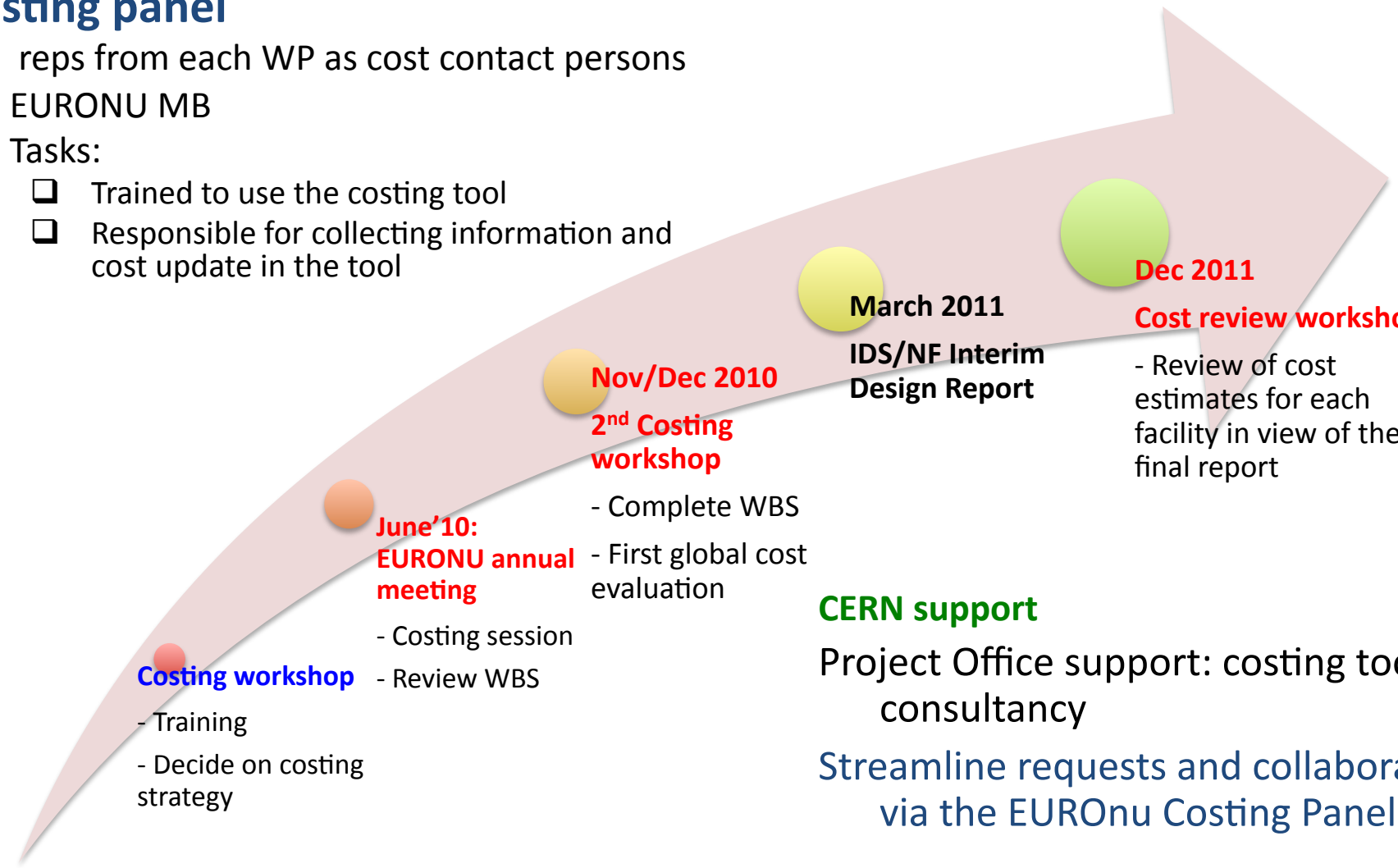
EUROnu should remain as the master project to assure sharing of information and studies between the options

- IDS-NF agreed to use the same tool for the cost evaluation
  - However this involves additional options on sites/detectors
  - Can this also provide additional help and knowledge for costing issues – engineering manpower?

EUROnu Costing exercise – Roadmap

Costing panel

- reps from each WP as cost contact persons
- EURONU MB
- Tasks:
  - Trained to use the costing tool
  - Responsible for collecting information and cost update in the tool

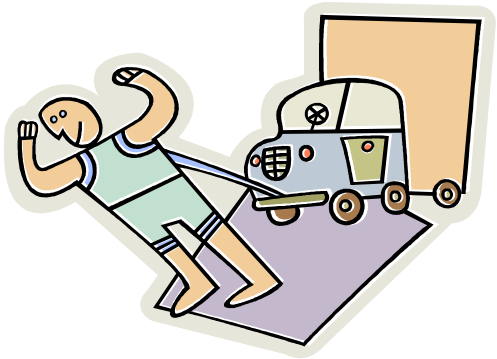


CERN support

Project Office support: costing tool, consultancy

Streamline requests and collaboration via the EUROnu Costing Panel

EUROnu Costing exercise – Challenges ahead



- The manpower will be the limiting factor
  - Several parts of each facility NOT included in the EURONU
  - Parts are only designed not fully engineered
  - Balance of available manpower between physics (design/simulation) and engineering
  - Available expertise in infrastructure estimates?
  - Localization exercises
    - would need local experts to get estimates – CERN?
    - include safety issues and impact on cost
- Final target for cost estimate in the final report?
  - ± 50 % (±30)? – what is realistic and "politically correct" at this stage?
  - Aim for better precision on the relative cost between facilities – ±30 or less??

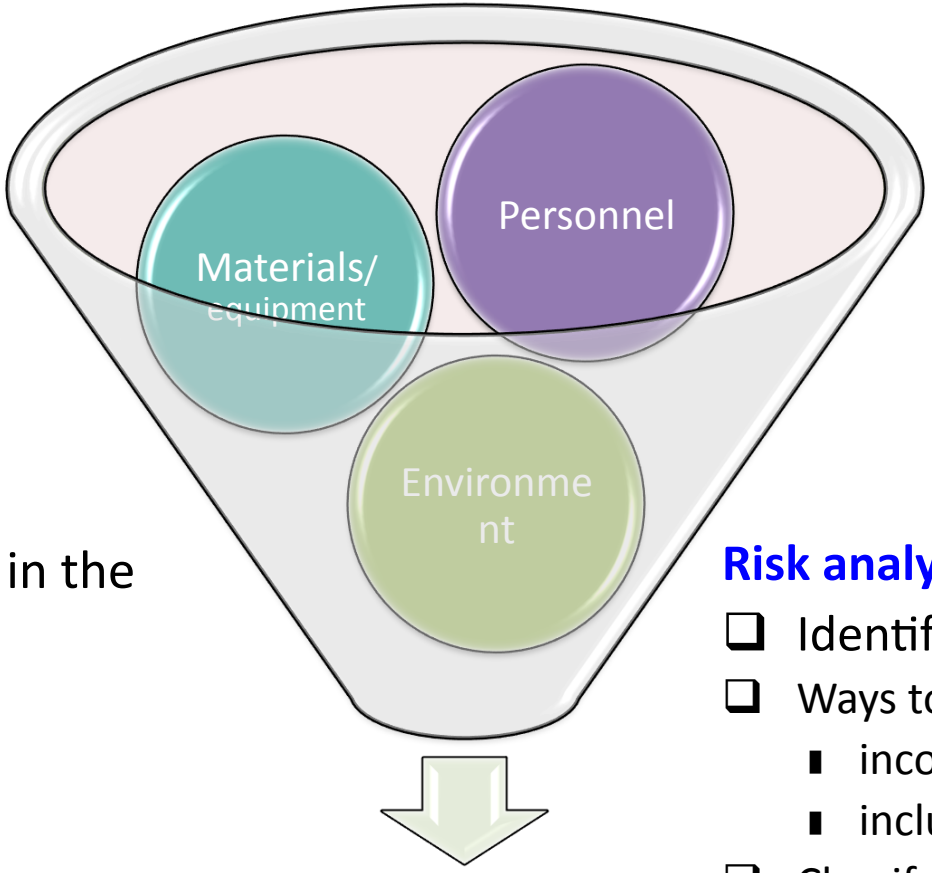
SAFETY

EUROnu Safety – What it means?

- Identify safety issues in the project
  - Safety of **personnel** during installation, operation, maintenance and dismantling actions
  - Safety to **materials/equipment** – assure their operation as required by the specs
  - Impact to the **environment** during installation, operation and dismantling of the facility

- Do risk analysis for each identified safety issue
  - Ways to mitigate the risk → incorporate in the design, include in the cost estimate
  - Classify the risks → setup the project risk register

EUROnu Safety – What it means?



Identify safety issues in the project during:

- installation
- operation
- maintenance
- .. and dismantling

Risk analysis

Risk analysis:

- Identify risks (wrt safety)
- Ways to mitigate the risks
  - incorporate in the design
  - include in the cost estimate
- Classify the risks
  - setup the **project risk register**

EUROnu Safety – Roadmap

Safety panel

- reps from each WP as cost contact persons
- EURONU MB
- Tasks:
  - Collect information on safety issues
  - Organize risk analysis reviews

- **Safety = Costing Panel???**