FUTURE CIRCULAR COLLIDER

Procurement Strategies for LHC and a forward outlook for FCC

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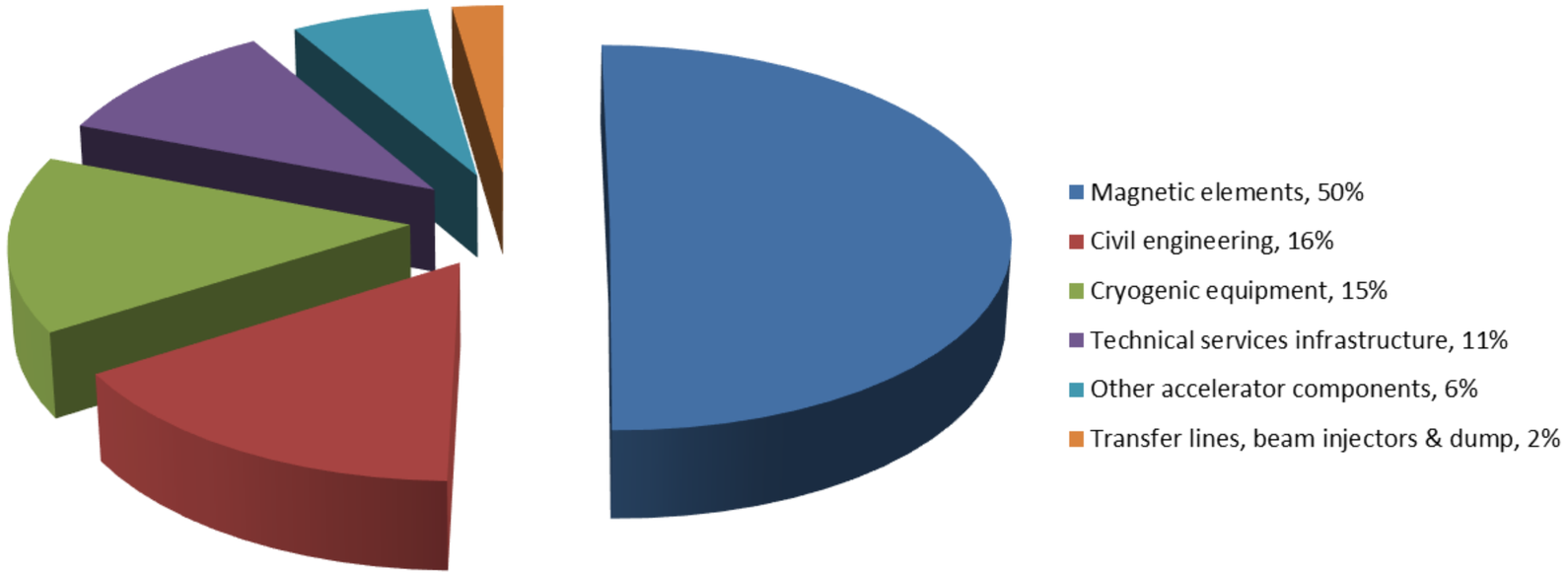
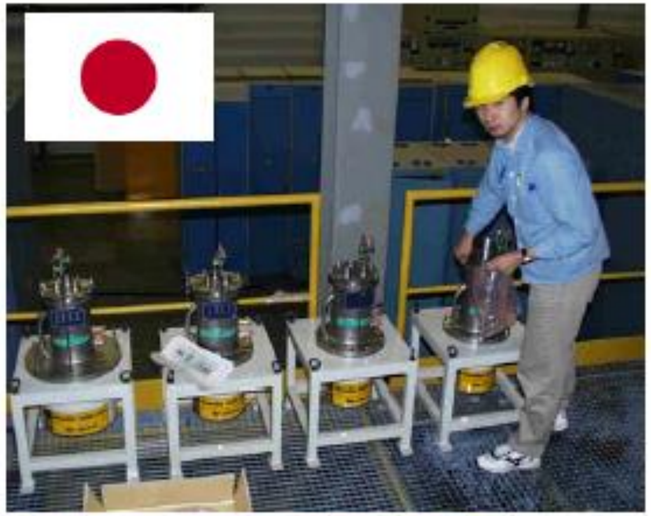
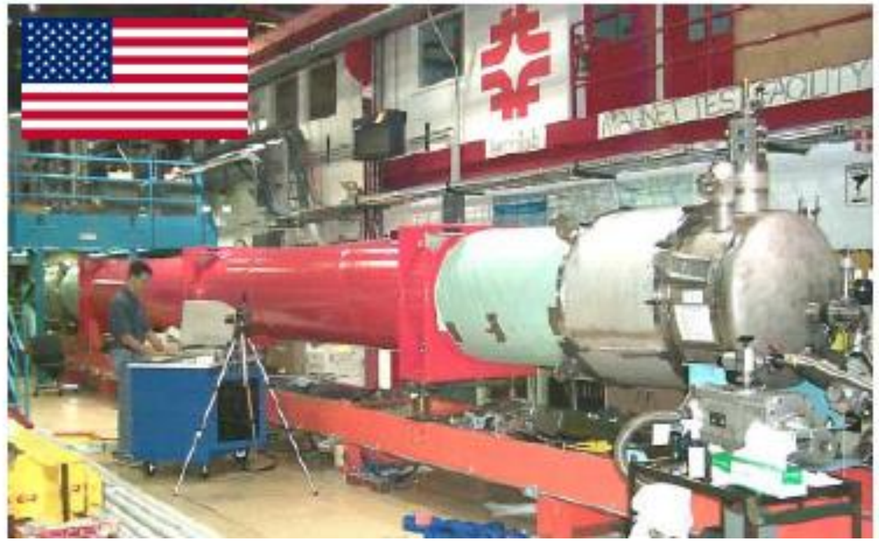
Cost structure of the LHC

Total material cost for the accelerator only: 3.8 BCHF



A global project spanning space…





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…and time

• Preliminary conceptual studies	1984
• First magnet models	1988
• Start structured R&D program	1990
• Approval by CERN Council	1994
• Industrialization of series production	1996-1999
• Start civil works	1998
• Adjudication of main procurement contracts	1998-2001
• Start installation in tunnel	2003
• Cryomagnet installation in tunnel	2005-2007
• Functional test of first sector	2007
• Commissioning with beam	2008
• Operation for physics	2009
• (HL-LHC (upgrade) operation	2029-2041)

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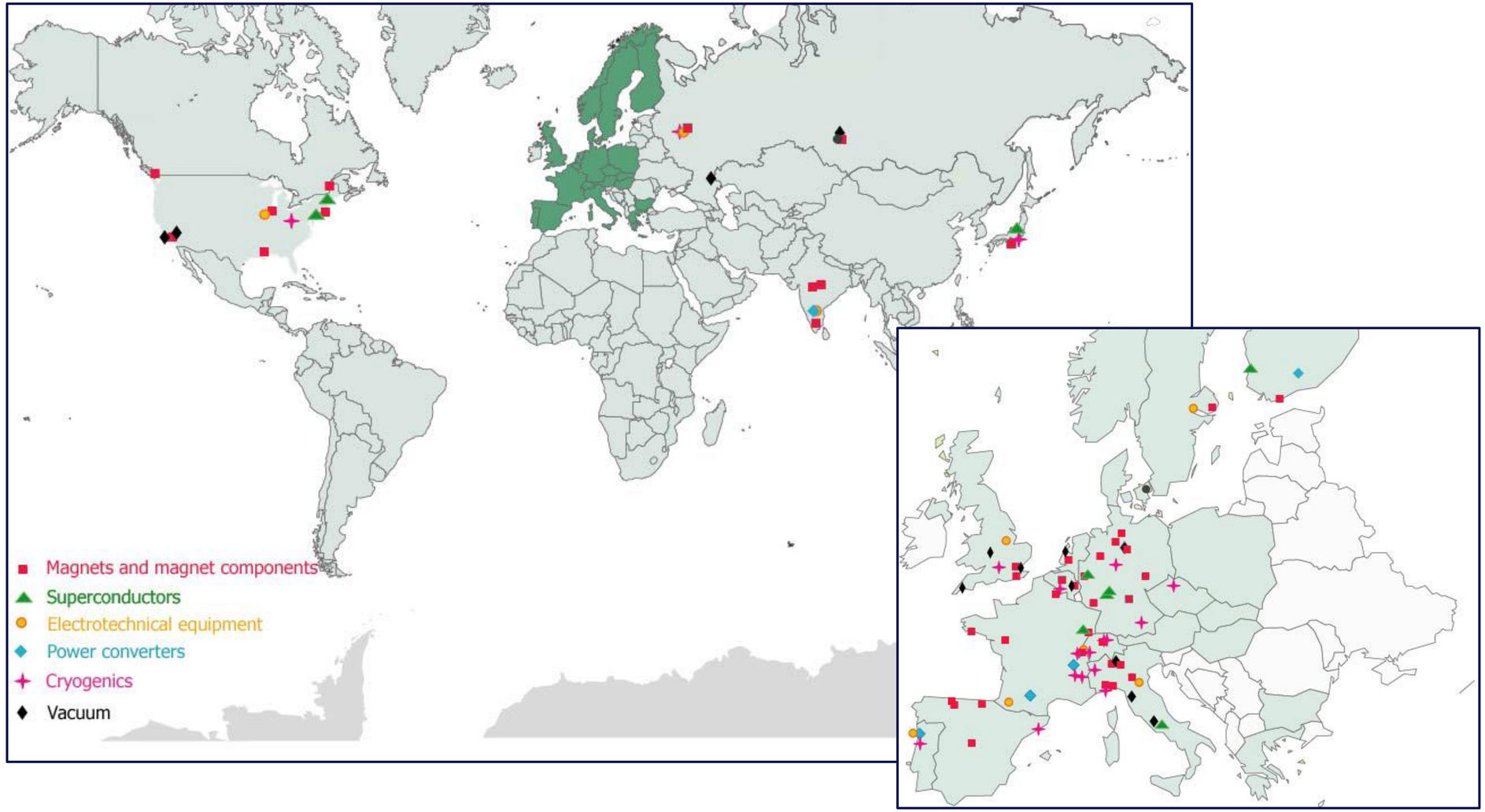
…and huge volumes

- **1 170** price enquiries and invitations to tender (> 50 kCHF each);
- **115 700** purchase orders (< 750 kCHF each)
- **1 040** contracts of various types and amounts;
- **6 364** different suppliers and contractors (not including subcontractors).

Covering

- standard off-the-shelf items
- the development and manufacturing of equipment in accordance with functional specifications
- Build-to-print items

90 high-tech industrial contracts in the world



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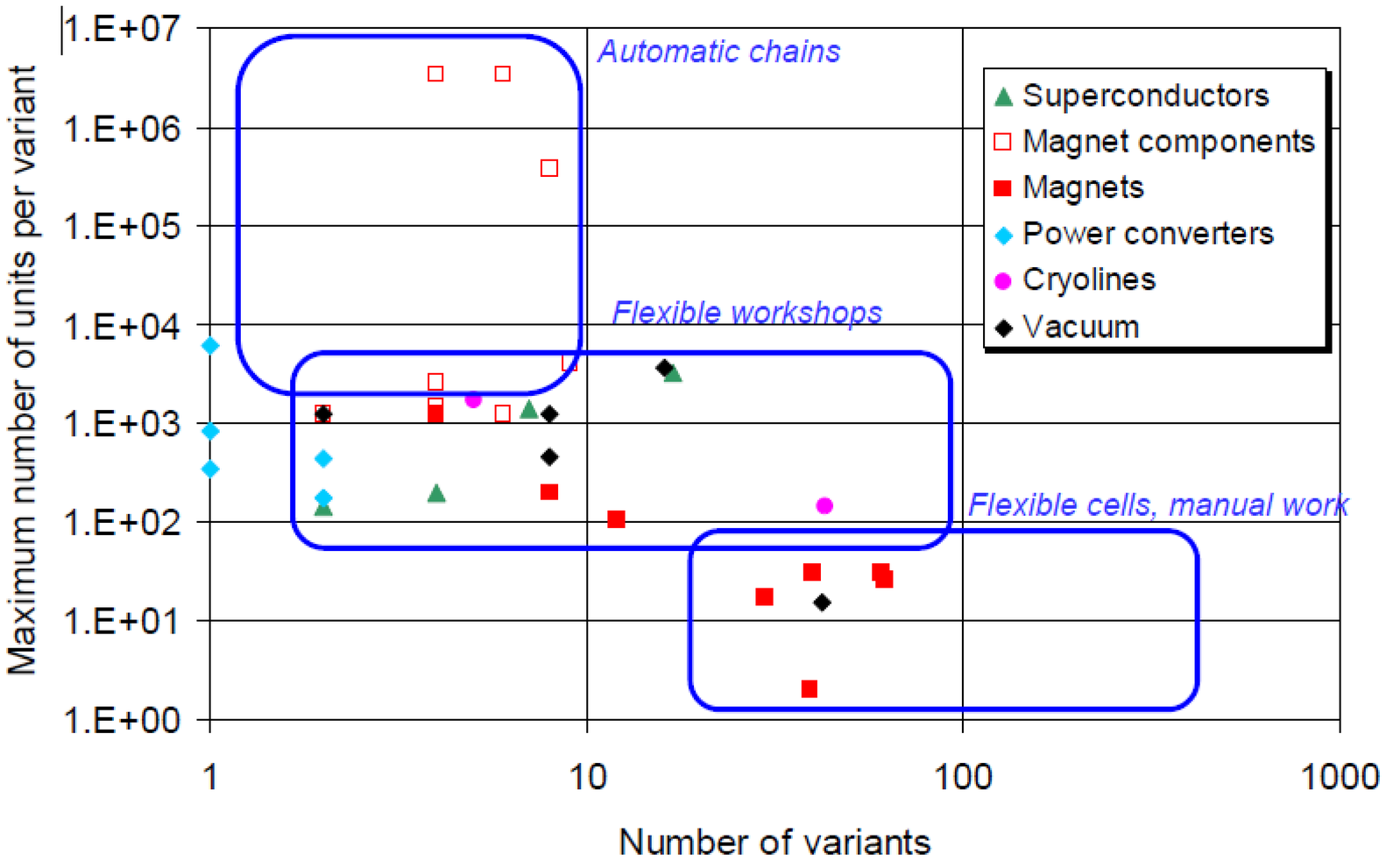
Production volumes of LHC components



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Experimental learning curves

LHC superconducting dipole magnets

- Unit cost c(n) of nth unit produced

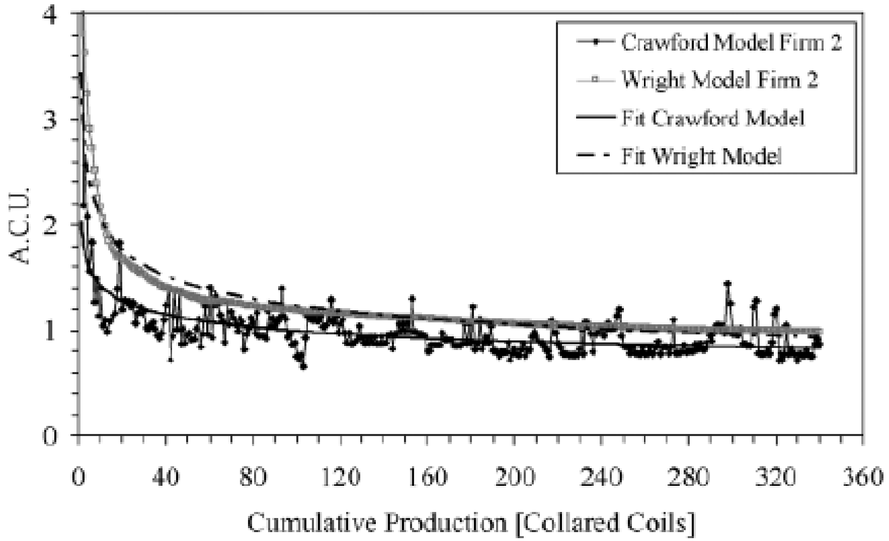
$$c(n) = c(1)\, n^{\log_2 a}$$

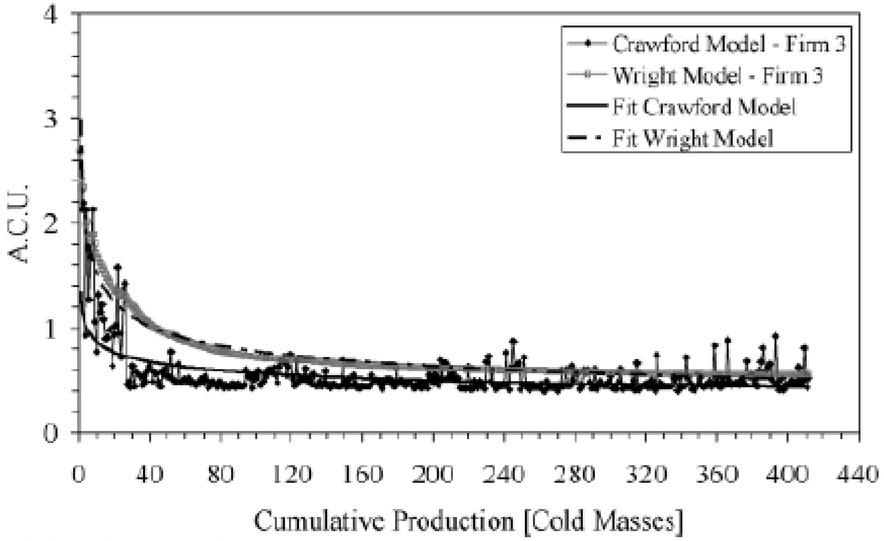
with a = « learning percentage », i.e. remaining cost fraction when production is doubled

- Cumulative cost of first nth units

$$C(n) = c(1)\, n^{1+\log_2 a} / (1+\log_2 a)$$

with C(n)/n = average unit cost of first nth units produced





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Experimental learning curves

Learning coefficients

TABLE IV
LEARNING PERCENTAGE OF SELECTED REFERENCE INDUSTRIES

Industry	ρ
Complex machine tools for new models	75%-85%
Repetitive electrical operations	75%-85%
LHC magnets	80%-85%
Shipbuilding	80%-85%
Aerospace	85%
Purchased Parts	85%-88%
Repetitive welding operations	90%
Repetitive electronics manufacturing	90%-95%
Repetitive machining or punch-press operations	90%-95%
Raw materials	93%-96%

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From LHC to HL-LHC and FCC

Specification & procurement strategy based on lessons learned

- Legal/regulatory framework;
- Procurement strategy and invitation to tender;
- Contract.
- What’s in it for the contractors?

Legal/regulatory framework

- Available governance, funding, corporate culture, staff, rules and processes?
- Seeking « fair return » among CERN Member States?
- Handling special « in-kind» contributions:
  - In-kind reduces contracts handled by one single procurement service;
  - However, may be more difficult to handle changes;
  - May reduce possibility for standardization.

Procurement strategy and Invitation to tender

Manage Risk

Manage risk as this will help decide the strategy. Risks should be borne by the owner of the technology, i.e. the party who knows most about the risks concerned and has the possibility to control them.

- Make or Buy? Taking into account potential suppliers and contractual risks
- Technical specification: functional & interface vs. build-to-print?
- Dual sourcing vs. Single sourcing? Security of supply & balanced return vs. additional follow-up
- Act as general contractor managing the supply chain?

Benefits	*Risks & drawbacks*
• Technical homogeneity • Quality assurance • Economy of scale • Safety of supply • Balanced industrial return	• Responsibility interface • Additional workload • JIT breakdown • Transport, storage, logistics

Different contracts require different strategies

Courtesy of Philippe Lebrun

Procurement strategy and Invitation to tender

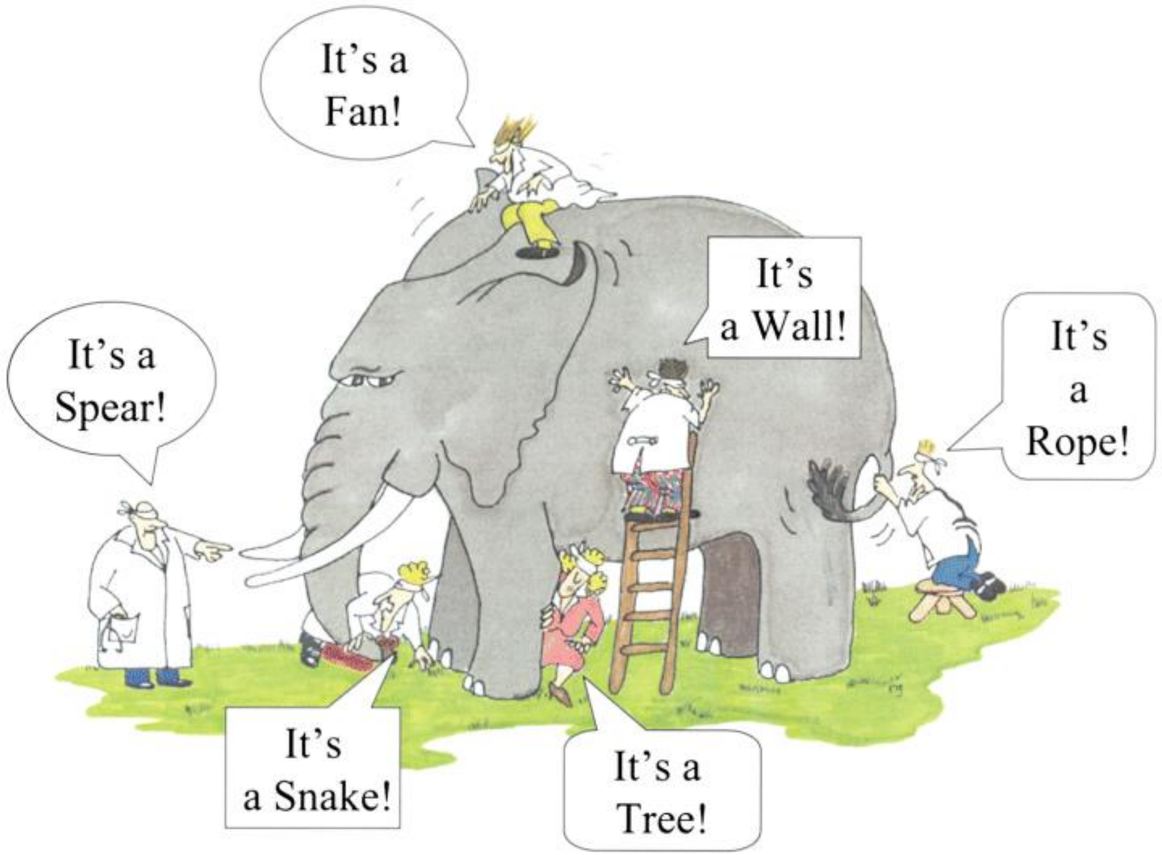
Ensure competition

- Cooperation with industry is essential from early stages of a project in order to achieve success within business constraints.
- Attract interest from industry by organizing workshops (e.g. HL-LHC Industry days, BSBF, etc).
- Identify areas/domains with a lack of firms in order to source potential suppliers.
- Publish information.
- Select the right companies.
- Building know-how & maintaining interest through prototyping, pre-series and series in a one-of, technically risky supply contract.
- Competition with other products/markets.
- Consider producing prototypes in-house and keep the production line as spare in case industry fails.

Procurement strategy and Invitation to tender

Specify the requirements

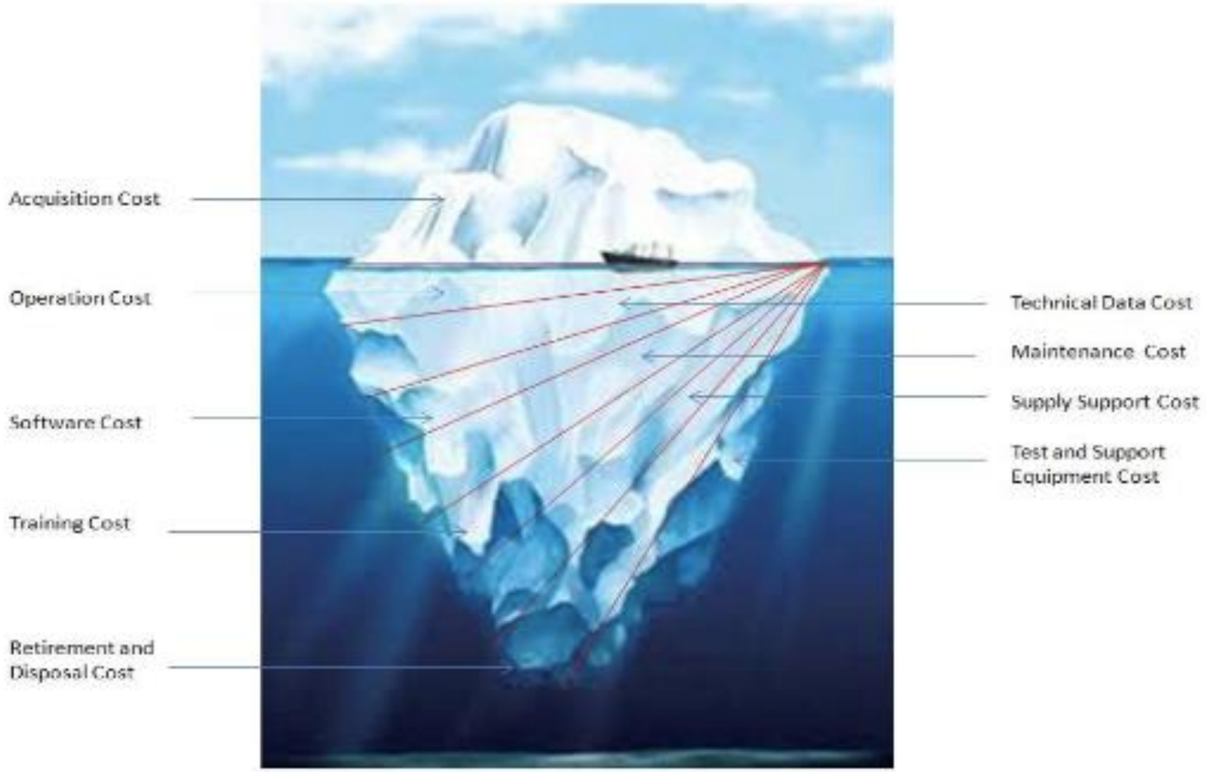
- Technical specification: functional & interface vs. build-to-print?
- Clear, unambiguous, realistic. Avoid gold plated specifications (in particular taking into account long series productions)
- Identify responsibility for dealing with potential risks
- Quality control, testing and acceptance procedures
- Review by an “independent” specification committee
- invitations to tender should not be issued until the requirements are well understood and can be clearly specified, because **Amendments cost time and money!**



Procurement strategy and Invitation to tender

Drafting and issuing the tender documents

- Total tender amount, include all relevant cost elements (TCO):
  - Design
  - Manufacture
  - Installation
  - Operation (including energy)
  - Maintenance
  - Spares
  - Consumables, etc..
  - training of personnel,
- Learning curves?
- Best value for money?
- Sustainability criteria???



Contract

- Avoid unreasonable contract conditions, e.g. concerning liability. Risks should be borne by the party in the best position to control them.
- Achieving quality throughout the project involves the establishment and enforcement of a comprehensive QAP:
  - Configuration management, engineering data management
  - Manufacturing and test plan
  - Inspection (QA inspectors?)

- Maintaining sufficient resources in the home laboratory is necessary to cope with:
  - tasks outside the interest and capabilities of industry
  - unexpected technical or commercial difficulties

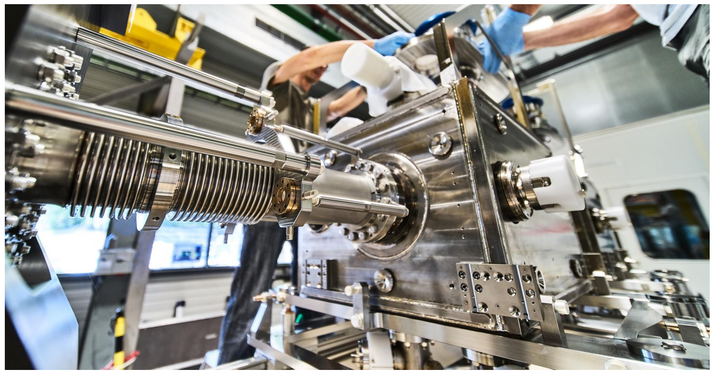
- Be aware of a possible “grab-and-run” attitude from suppliers and contractors

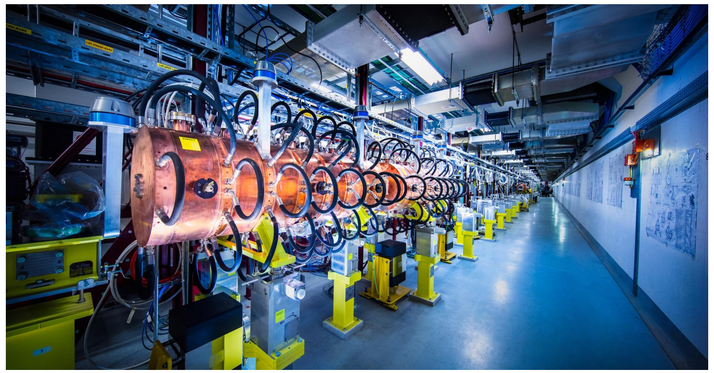
…FCC time schedule

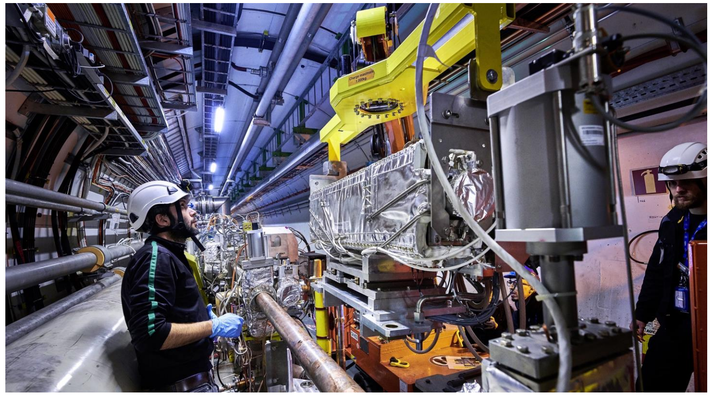
• Conceptual design studies	2014-2018
• Feasibility study	2021-2025
• Approval by CERN Council	~2028
• Start civil works	~2030
• HL-LHC ends	~2041
• Start of FCC-ee	~2045
• Operation for physics of FCC-ee	~2048-2063
• Construction of FCC-hh	~2058-2070
• Operation for physics of FCC-hh	~2070-2095

Examples of FCC items to be contracted

- Injectors
- Warm magnets
- SC magnets
- Power converters
- Electricity distribution and material
- Cooling, ventilation, water distribution (incl heat recovery)
- Machine protection
- Vacuum
- RF
- Collimators and absorbers
- Beam transfer
- Beam dump
- Beam diagnostics and instrumentation
- Supports and girders
- Polarisation and energy calibration
- Geodesy and survey
- Cryogenics
- Information, communication and controls
- Robotics
- Civil engineering
- Experiments
- Safety, environment and RP
- Excavated materials management
- logistics and transports





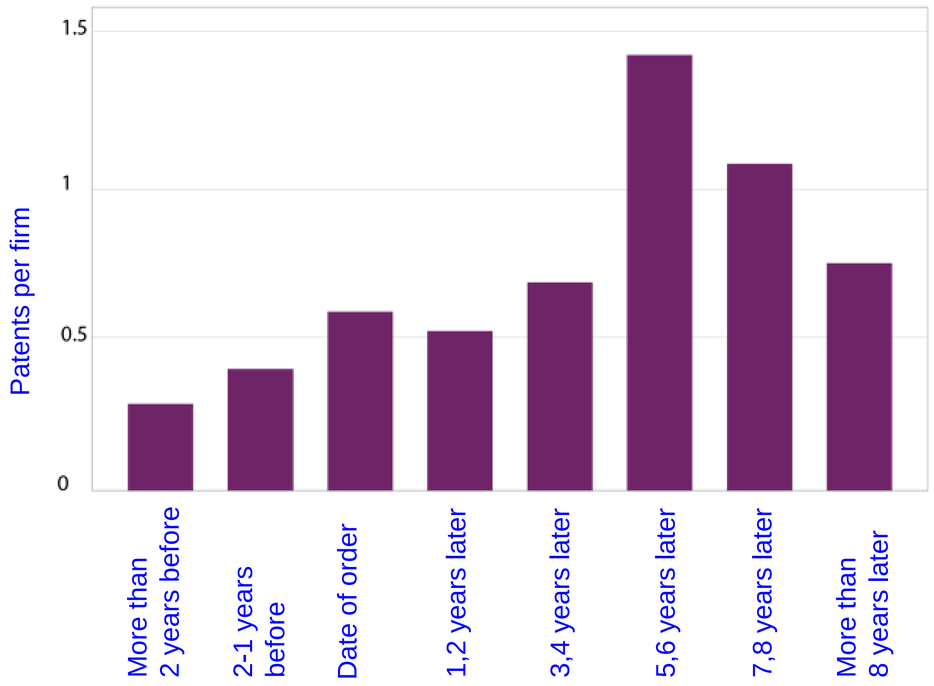


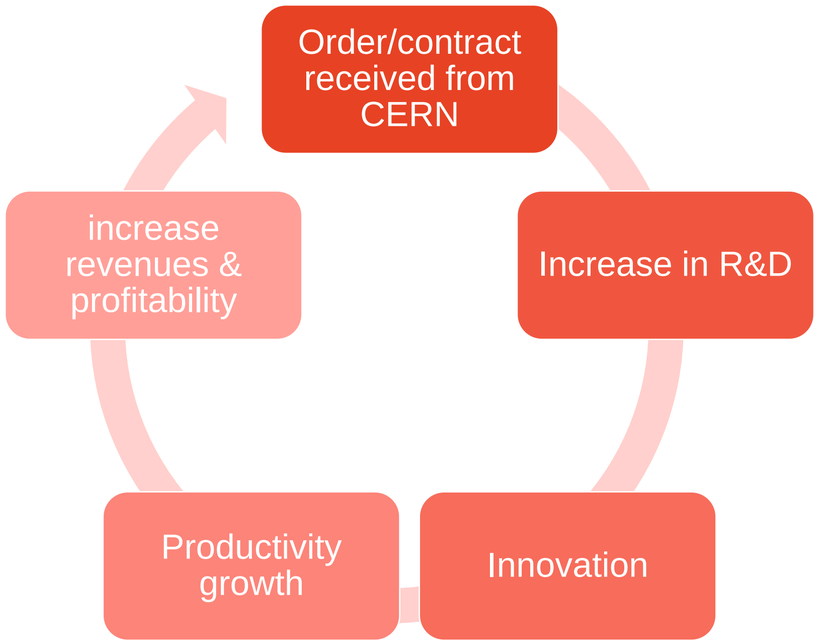
The economical impact of CERN Procurement on supplier's performance (Castelnovo et al, 2018)

Empirical studies (by the analysis of financial data from 1995 to 2008 from 365 CERN suppliers for the LHC) show that after working with CERN on high-tech contracts, CERN suppliers out-perform their peers by:

Investing more in R&D and filing more patents

Higher productivity, revenue and profitability





Doing business with CERN: the facts

supplier survey (669 suppliers in 33 countries, 2017):

48%
improved products and services

42%
developed new products

55%
improved technical knowledge in their field

18%
found or opened a new market to address

62%
used CERN as a marketing reference

Thanks for your attention!