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

- Magnetic elements, 50%
- Civil engineering, 16%
- Cryogenic equipment, 15%
- Technical services infrastructure, 11%
- Other accelerator components, 6%
- Transfer lines, beam injectors & dump, 2%
A global project spanning space…

Slide courtesy of Philippe Lebrun
...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)
...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

Slide courtesy of Philippe Lebrun
Production volumes of LHC components

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Experimental learning curves

LHC superconducting dipole magnets

- **Unit cost c(n) of nth unit produced**
  \[ c(n) = c(1) \cdot n^{\log_2 a} \]
  with \( a \) = « learning percentage », i.e. remaining cost fraction when production is doubled

- **Cumulative cost of first nth units**
  \[ C(n) = c(1) \cdot n^{1+\log_2 a} / (1+\log_2 a) \]
  with \( C(n)/n \) = average unit cost of first nth units produced

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Experimental learning curves

Learning coefficients

TABLE IV

<table>
<thead>
<tr>
<th>Industry</th>
<th>( \rho )</th>
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</thead>
<tbody>
<tr>
<td>Complex machine tools for new models</td>
<td>75%-85%</td>
</tr>
<tr>
<td>Repetitive electrical operations</td>
<td>75%-85%</td>
</tr>
<tr>
<td>LHC magnets</td>
<td>80%-85%</td>
</tr>
<tr>
<td>Shipbuilding</td>
<td>80%-85%</td>
</tr>
<tr>
<td>Aerospace</td>
<td>85%</td>
</tr>
<tr>
<td>Purchased Parts</td>
<td>85%-88%</td>
</tr>
<tr>
<td>Repetitive welding operations</td>
<td>90%</td>
</tr>
<tr>
<td>Repetitive electronics manufacturing</td>
<td>90%-95%</td>
</tr>
<tr>
<td>Repetitive machining or punch-press operations</td>
<td>90%-95%</td>
</tr>
<tr>
<td>Raw materials</td>
<td>93%-96%</td>
</tr>
</tbody>
</table>

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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?

Different contracts require different strategies

**Benefits**
- Technical homogeneity
- Quality assurance
- Economy of scale
- Safety of supply
- Balanced industrial return

**Risks & drawbacks**
- Responsibility interface
- Additional workload
- JIT breakdown
- Transport, storage, logistics

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.
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
Anders Unnervik and Lucio Rossi

...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
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!