Construction schedule for CFS

Agenda:

→ Scope of CFS scheduling exercise
→ Method to make time estimates
→ Year by year schedule
→ Conclusion
Scope of CFS scheduling exercise

→ Valid for Europe (both sample sites) and Americas
→ Based on input from:
  → Amberg Engineering Ltd for Civil engineering work
  → LHC project for tunnel construction & CFS services installation
  → CMS project for surface buildings and detector hall construction and CFS services installation
Method to make time estimates

→ Use the completion examination of LHC and CMS work and scale it to ILC project
→ Based on a real life similar project

Cranes
Electrics
Civil Engineering
Cooling and Ventilation
Schedule of underground Civil Engineering work

→ RTML + Main Linac + BDS + DRs schedule for
  → CERN and Americas
  → DESY

→ Day 1 is the kick off date of the ILC project
  → Detailed design and tender documents completed

→ Compatible with a 7-year project construction time

→ Shaft and caverns excavation includes the primary lining of the shaft base caverns and the final lining of the shaft. The finishing of the caverns only take place once no spoil is taken out from the shaft anymore.

→ DR schedule displayed independently
CERN and Americas: Year 1

→ Market surveys, call for tenders and contractor selection
→ Building permits, Environmental impact studies, Purchase of land
→ Based on experience with LHC - Implies having a frozen design!

<table>
<thead>
<tr>
<th>Year/Kins</th>
<th>P.1</th>
<th>P.2</th>
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<th>Y15</th>
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</table>

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CERN and Americas: Year 2

→ Shafts excavation

→ Surface buildings
  → Service buildings
  → Part of surface detector building (CMS)

11 shafts have to be started together

To be build when Underground hall complete

2/3 of building for detector assembly
“When civil engineering work is so long that beneficial occupancy of the experimental cavern could be late, CMS has introduced from the onset the concept of constructing and testing the detector on the surface before transfer underground by heavy lifting means. This concept has proved quite successful”

A Herve - CMS technical coordinator

Key facts:

- Work executed underground requires 50% more time than if performed on the surface and can be at least 30% more expensive

- Extra costs attached to the CMS concept:
  - Heavy lifting equipment (1.2MCHF for CMS)
  - Large detector assembly building (3 MCHF for CMS)
  - Both costs are already included in the CFS cost estimates for EU sites
Caverns excavation work includes preliminary lining to allow the setup of TBMs.

- **TBM $\phi$ finished = 5m**
- **TBM $\phi$ finished = 4m**
- **TBM $\phi$ finished = 6.5m option**
- **MS TBM $\phi$ = 5m**
- **Cavern finishing**

**Key:***
- Red: Shaft/cavern excavation
- Blue: TBM setup
- Yellow: TBM transport
- Purple: TBM removal
- Green: Finishing work
CERN and Americas: Year 3

→ Set-up and launch of TBMs both for RTML, ML, BDS and DRs
→ Completion of shafts excavation
→ Detector halls construction

9 TBMs have to be started together
+2 for DRs

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9 TBMs
Different ⌀ to accommodate design
Detector hall construction starts when shafts are complete.

End of evacuation of spoil defines when the finishing of a shaft base cavern can start.

- **TBM \( \varnothing_{\text{finished}} = 5 \text{m} \)**
- **TBM \( \varnothing_{\text{finished}} = 4 \text{m} \)**
- **TBM \( \varnothing_{\text{finished}} = 6.5 \text{m option} \)**
- **MS TBM \( \varnothing = 5 \text{m} \)**
- **Cavern finishing**

**Shaft/cavern excavation**
- **TBM setup**
- **TBM transport**
- **TBM removal**
- **Finishing work**
CERN and Americas: Year 4

→ Most resource intensive year:
  → 10 TBMs in action for RTML, ML, BDS + 2 for DRs
  → Completion of detector halls + on-going work for shaft base caverns
  → Finishing of tunnels + start of CFS services installation
10 TBMs for RTML, ML, BDS
But 3 are transported and reused
Base shaft caverns finishing starts

- TBM \( \varnothing_{\text{finished}} = 5m \)
- TBM \( \varnothing_{\text{finished}} = 4m \)
- TBM \( \varnothing_{\text{finished}} = 6.5m \) option
- MS TBM \( \varnothing = 5m \)
- Cavern finishing
- Shaft/cavern excavation
- TBM setup
- TBM transport
- TBM removal
- Finishing work
Finishing work for tunnel:
Floor, drainage, painting…

- TBM $\varnothing_{\text{finished}} = 5m$
- TBM $\varnothing_{\text{finished}} = 4m$
- TBM $\varnothing_{\text{finished}} = 6.5m$ option
- MS TBM $\varnothing = 5m$
- Cavern finishing

Shaft/cavern excavation
TBM setup
TBM transport
TBM removal
Finishing work
CERN and Americas: Year 5

→ Last year of underground CE work:
  → Extraction of TBM's
  → Start of installation for infrastructure in Detectors Halls
  → Completion of shaft base caverns
  → Finishing of tunnels + CFS services installation
Extraction of TBMs

- TBM $\emptyset_{\text{finished}} = 5m$
- TBM $\emptyset_{\text{finished}} = 4m$
- TBM $\emptyset_{\text{finished}} = 6.5m$ option
- MS TBM $\emptyset = 5m$
- Cavern finishing

Shaft/cavern excavation
TBM setup
TBM transport
TBM removal
Finishing work

Extraction of TBMs
Install CFS services in Detector halls & Shaft base caverns
CFS services installation schedule for Detector Halls and Base Shaft Caverns

→ Based on experience with CMS
→ Time estimates for site work only

<table>
<thead>
<tr>
<th>Cavern</th>
<th>Dimensions L x W x H</th>
<th>Metallic structures</th>
<th>Cooling and ventilation</th>
<th>Electrics General Services</th>
<th>Crane installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMS</td>
<td>53 x 26 x 25</td>
<td>5w</td>
<td>19w</td>
<td>10w</td>
<td>1w</td>
</tr>
<tr>
<td>ILC detector halls</td>
<td>72 x 32 x 35</td>
<td>9w</td>
<td>36w</td>
<td>19w</td>
<td>2w</td>
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<tr>
<td>ILC Shaft base caverns</td>
<td>50 x 14.5 x 18</td>
<td>3w</td>
<td>10w</td>
<td>5w</td>
<td>1w</td>
</tr>
</tbody>
</table>

Completion examination figures

Estimates
CFS services installation schedule for Detector Halls and Base Shaft Caverns

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Duration</th>
<th>Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Underground Detector Hall</td>
<td>235 days</td>
<td></td>
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<tr>
<td>2</td>
<td>Detector Hall construction complete</td>
<td>0 days</td>
<td>TS-CE</td>
</tr>
<tr>
<td>3</td>
<td>Install metallic structures</td>
<td>9 wks</td>
<td>TS-IC</td>
</tr>
<tr>
<td>4</td>
<td>Install overhead crane</td>
<td>2 wks</td>
<td>TS-IC-HM</td>
</tr>
<tr>
<td>5</td>
<td>Install cooling and ventilation</td>
<td>36 wks</td>
<td>TS-CV</td>
</tr>
<tr>
<td>6</td>
<td>Install EL general services</td>
<td>19 wks</td>
<td>TS-EL</td>
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<tr>
<td>7</td>
<td>Shaft Base Caverns</td>
<td>70 days</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Cavern construction complete</td>
<td>0 days</td>
<td>TS-CE</td>
</tr>
<tr>
<td>9</td>
<td>Install metallic structures</td>
<td>3 wks</td>
<td>TS-IC</td>
</tr>
<tr>
<td>10</td>
<td>Install overhead crane</td>
<td>1 wk</td>
<td>TS-IC-HM</td>
</tr>
<tr>
<td>11</td>
<td>Install cooling and ventilation</td>
<td>10 wks</td>
<td>TS-CV</td>
</tr>
<tr>
<td>12</td>
<td>Install EL general services</td>
<td>5 wks</td>
<td>TS-EL</td>
</tr>
</tbody>
</table>

→ CFS services ready:
   → Detector Halls: 11 months after hall construction complete
   → Ready for detectors: end of year 5 (possible overlap with CV)
   → Pre-commissioning done in surface building
   → Shaft base caverns: 3 months after cavern completion
CFS services installation in detector hall
CERN and Americas: Year 6

→ Installation of infrastructure in all caverns
→ Installation of infrastructure in tunnels
→ Construction of Shaft access buildings
→ Construction of extension for detector building to cover shafts
CMS approach

→ Detectors are assembled on the surface
  → Assembly runs in parallel with underground work
  → Allows a pre-commissioning before lowering
  → Lowering using dedicated heavy lifting equipment
CMS approach

2/3 of Assembly building

Extension built once Detector Hall cavern complete
Building and CFS services installation schedule for shaft access buildings

→ Based on experience with CMS
→ Time estimates for site work only

<table>
<thead>
<tr>
<th>Building</th>
<th>Dimensions L x W x H</th>
<th>CE work Slab, shaft head</th>
<th>Metallic structures</th>
<th>Cooling and ventilation</th>
<th>Electrics General Services</th>
<th>Crane installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMS SDX5</td>
<td>36 x 17 x 15.5</td>
<td>15w</td>
<td>17w</td>
<td>18w</td>
<td>12w</td>
<td>1w</td>
</tr>
<tr>
<td>ILC Shaft access building</td>
<td>30 x 12 x 12</td>
<td>9w</td>
<td>8w</td>
<td>8w</td>
<td>5w</td>
<td>1w</td>
</tr>
</tbody>
</table>

Completion examination figures

Estimates
## Installation schedule for shaft access buildings

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Duration</th>
<th>Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Shaft access building</td>
<td>200 days</td>
<td>TS-CE</td>
</tr>
<tr>
<td>14</td>
<td>Shaft Base Cavern construction complete</td>
<td>0 days</td>
<td>TS-CE</td>
</tr>
<tr>
<td>15</td>
<td>Concrete slab</td>
<td>9 wks</td>
<td>TS-CE</td>
</tr>
<tr>
<td>16</td>
<td>Install shaft with infrastructure</td>
<td>12 wks</td>
<td>TS-CE</td>
</tr>
<tr>
<td>17</td>
<td>Build steelworks</td>
<td>8 wks</td>
<td>TS-CE</td>
</tr>
<tr>
<td>18</td>
<td>Install overhead crane</td>
<td>1 wk</td>
<td>TS-IC-HN</td>
</tr>
<tr>
<td>19</td>
<td>Install cooling and ventilation</td>
<td>10 wks</td>
<td>TS-CV</td>
</tr>
<tr>
<td>20</td>
<td>Install EL general services</td>
<td>5 wks</td>
<td>TS-EL</td>
</tr>
</tbody>
</table>

→ Bigger shaft access building complete in 10 months
→ A 12 week window is needed to install CFS infrastructure in shaft:
  → Concrete lift modules
  → Ventilation ducts
  → Cooling pipes
  → Cable trays
  → Metallic staircase
→ Last shaft access building complete by middle of Year 6
Crane

Ventilation ducts

Concrete lift modules

Metallic staircase

Building complete
DESY: Civil engineering schedule

16 TBMs needed for RTML, ML, BDS + 2 for DRs
Schedule compatible with CERN for surface buildings
Conclusions

→ Key milestones:
  → Detector Assembly Building ready for detector: \( t = t_0 + 3Y \)
  → First tunnel sections ready for services installation: \( t = t_0 + 4Y \)
  → DR ready for services: \( t = t_0 + 4Y \) (1 year procurement + 1 year shafts excavation + 1y10m TBM + 2m TBM extraction)
  → Detector Hall (cavern) ready for detector: \( t = t_0 + 4Y11m \)
  → All Base Shaft Caverns equipped with services: \( t = t_0 + 4Y11m \)

→ More efforts needed to reach reliable time estimates for the CFS services installation in the tunnels

→ CFS group is ready to take part in the consolidation of a general schedule including cryogenics, vacuum pipes and detectors installation which could be presented at the Valencia meeting…