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ENGINEERING THE COOLING AND VENTILATION FOR THE LHC

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Abstract

Early in the LHC-project, a decision was made to complete in-house, as much of the engineering for the new cooling and ventilation systems as was practicable. This is achieved using the competence of resident (CERN staff) engineers for the studies, project management, on-site installation, supervision, etc. The documentation has however, been compiled using the format of tender drawings in the technical office by industrial service personnel. This model, adopted by the Cooling and Ventilation (CV) group is attractive from the viewpoint of conservation of "know-how" within CERN. The main difficulty is however, to be able to absorb such an important project within available manpower. This paper will revisit the arguments behind this method as well as summarize the results to date. Finally, the author will outline other methods (followed by other groups within the project), for a comparison with the model chosen by ST/CV.

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1 INTRODUCTION

The engineering-phase of the cooling and ventilation systems for the LHC-machine and its experimental areas is now well advanced, using an engineering-model in which the resident engineers in the group exercise a key-role for the development of the various systems. The technical office is, however staffed dominantly by industrial support personnel, thus a partial outsourcing of the design.

2 BACKGROUND

In order to fully understand why the decision was taken to execute a major portion of the engineering studies for LHC in-house, a quick summary of the situation in 1994/5 –when the LHC project was approved- is provided below.

The Cooling and Ventilation activities were at this time divided into two groups, the ST/CV and the AT/CV. AT/CV group were in charge of the main LEP-construction and ST/CV were responsible for all other machines as well as cooling and ventilation for buildings and infrastructure. The two groups were unified at the end of 1995. Although the combination provided solid competence as well as experience, the staff profile was not fully adapted to take on such an engineering challenge as was expected with LHC for the following reasons:

- The age profile showed that a good part of the CERN staff would retire soon
- The group needed a reinforcement of engineering (academic) staff

Moreover, the group did not have a technical office with the design capacity to respond to such a project as LHC. Early cost estimates for the Cooling and Ventilation works for the LHC-project indicated that an investment of roughly 90’000’000 CHF was needed.

3 AVAILABLE OPTIONS

Three possible choices to this problem were identified:

a) Full outsourcing, included tender design and construction follow-up

b) No outsourcing at all

c) Partial outsourcing

a) The principle advantage of the first choice was that it would make it possible to adhere to the long term staffing reductions planned by the CERN management. However, in an area such as cooling and ventilation, which require a continuous full understanding of the special conditions in which these technologies have to apply, it would, not however, result in long term preservation of the necessary know-how of these installations for the commissioning and operation. It should also be mentioned that the cost, (exceeding 15%) of the installation cost, was not positively received when presented to the project management.

b) The second choice had the advantage that the know-how would be preserved over the longer term. A distinct disadvantage however, was that any large reduction in CERN staff would not be possible. Clearly this option was not coherent with long term staffing cuts so had to be eliminated.

c) The final choice which we have named partial outsourcing is in fact a "hybrid" of the first two options. In practice, the option consists of firstly a small reinforcement of the engineering staff (academic and technical engineers) within the group, thus, filling some of the gaps of the retiring colleagues. This in turn re-profiled the group towards an average higher academic level. Secondly, a technical office able to design with CERN standard, 3D-CAD (Euclid) was built up, based on industrial support personnel (Non-CERN staff). Benefits from this option can be summarized as follows:

- Relatively cost effective; an external cost(material budget) of approximately 6% was calculated
- A large part of the know-how for the continuation of the cooling and ventilation activities should still be possible to preserve
- Modifications in the ST/CV engineering during the course of LHC studies (induced mainly by other group's engineering changes), would not have disastrous effects on costs

4 METHODS

The cooling and ventilation group has adopted a project oriented structure to handle the LHC-sub projects (as well as other projects). A project leader is named for each specific project. This person should, over the whole project phase assure that the project is managed from the perspective of:

- Technical content
- Time
- Budget
- Interface to customer (s)

The technical office is under the responsibility of the Design section. The section leader supports each project leader with drawing resources so that the documentation is in phase with the progress of the project. The technical design work can be, very simplified, be illustrated in the figure below:

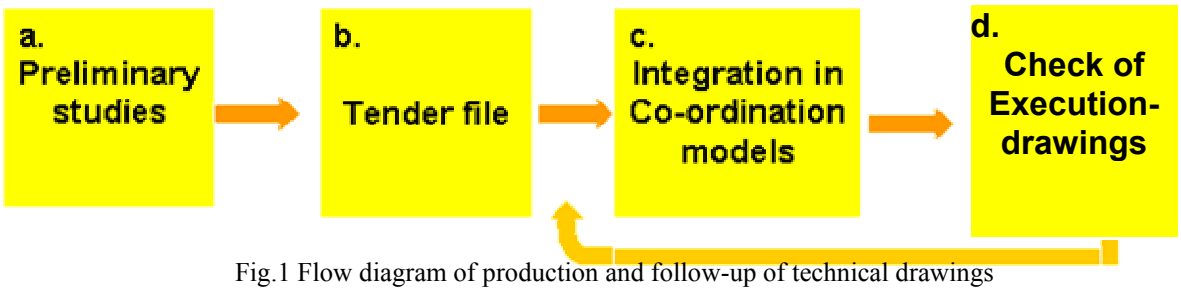

Fig.1 Flow diagram of production and follow-up of technical drawings

The proportion of the workload in the four described phases can be considerably different from one project-type to another. A project where the CV-group acts alone, e.g. the construction of a cooling tower, requires less effort in phase c. and d. compared to a project where the services from the CV-group are mixed with other installation, e.g. the fluid pipelines in the underground area.

Experience has shown that as for the first mentioned type of project, the provisions of drawing resources was reasonably well estimated, the resources for the integration studies in the underground areas were underestimated.

5 STATUS TODAY

An estimate on the status of the engineering studies for the Cooling and Ventilation studies for the LHC, based on the work-phases above is as follows (April 2003):

- 90 % of preliminary studies done
- 75% of tender studies done
- 60 % of co-ordination drawings done
- 40 % of all execution drawings done

6 PROBLEMS ENCOUNTERED

- As mentioned in § 4, the engineering studies in the LHC underground technical areas were under-estimated. In particular, the large amount of re-iterations due to technical difficulties to house all objects in a definite space with considerable increase of the thermal loads has put our technical office under great strain. The fact that the overall integration study for the project started very late, with a consecutive accelerated workload has not helped the situation.
- CERN's policy concerning the purchase of industrial support (re-tendering with 5 years interval with contract awarded to lowest bidder) has in the middle of the engineering study created a deep in-stability, with high turn-over of contract personnel.
- The CERN standard for 3D-drawings is based on a software-package (Euclid) which is outdated on the market. Available competence in industry is therefore very limited.

Moreover, the sometimes lack in synchronization between various trades, has put the technical office in additional difficulty.

7 COMPARING THE CV-MODEL WITH OTHER GROUPS

An interesting comparison can now be drawn by looking into the options selected by the other groups in the ST division, especially the Civil Engineering group (CE) and the Electric engineering group (EL), which both have LHC construction work in progress for an amount of the same magnitude as the CV-group.

7.1 Electric Engineering

The large proportion of repetitive standard components in the electric engineering systems has guided the group into a model where they tender for a large amount of standard equipment e.g. transformers, for which the company commits itself to provide a multiple of the specified equipment during a (normally 5 years) period at a set price list. The same applies to cabling, switchboards, etc. The project leaders in the EL-group have, therefore to specify the required amount, together with a schematic study. All components are thereafter ordered via service orders (detailed study included). The technical office has in charge, as consequence, mainly the integration studies, installation drawings, as well as the management of the detailed documentation. The staff in the technical office is, similarly to the CV-group, industrial support personnel.

The model adopted by the EL-group has proven successful, due to the good flexibility and reasonably short lead-time from order to installation. It is however difficult to apply a similar system to an area where a functional responsibility for an e.g. cooling plant, need to be assured by a construction company. In the area of "minor-works", we do apply a blanket order system, based on a pre-negotiated price list, very much similar to the EL-model.

7.2 Civil Engineering

The CE-group made early a policy-decision to not build up a structure for engineering studies for the LHC-cavern and new tunnels. The model which was adopted was a complete outsourcing of the construction design, work follow-up etc. Again, the decision was probably the best for the organization, where the in-house competence to build important new underground structures would not be exploited until long after the completion of LHC. It should here be noted that the project had to be very careful in changing the engineering design after a given date where the geometry should be considered frozen. The high cost as well as the required discipline, related to changes, made the model feel somewhat inflexible, but it would be difficult to really find alternatives to this.

8 CONCLUSIONS

A small staff of engineers in the Cooling and Ventilation group has, so far succeeded in the main (tender) engineering phase. Successful, in spite of an almost complete shift of generations in the engineering staff of the group. The model we selected to carry out these studies has given us a good compromise between flexibility and cost-effectiveness. We have, as described earlier in this report, during the course of the studies, met some problems, especially related to the external staffing of the technical office. Our colleagues in the EL & CE groups have chosen other options, with overall good result. There is therefore no reason to claim that any of our three groups should have selected an alternative path. Looking back, and in the light of the high turnover of industrial support staff, a couple of 3D-CAD designers as permanent (CERN) staff would have been an important contribution for a more efficient technical office.