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THE LHC EXPERIMENTS AS SEEN FROM THE TECHNICAL SECTOR

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Abstract

Since the beginning of the collaboration between the ST division and the LHC experiments, already in 1998, the technical sector has provided different structures for the support of the experiments, aiming to coordinate all the activities, which traditionally belong in the technical sector's mandate, like civil engineering and structures, cooling and ventilation, cranes and transport, electricity, gas, etc. A picture of the last year's activity, mainly concentrated on the ATLAS and CMS experiments, shows how the synergies between project managers, staff involved and group structures can strongly improve the service level in the technical domain. This closer collaboration has facilitated the development of further ties linked to the competence available in the groups, and of great interest to the experiments. The steady rise in demand confirms that the choice, made by the experiments, confirms that the technical sector support is a real need in this area

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1 INTRODUCTION

Since the beginning of the collaboration between the ST division and the LHC experiments (already in 1998) the technical sector has provided different means for the support of the experiments, aiming to coordinate all the activities, which traditionally belong in the technical sector's mandate (like civil engineering and structures, cooling and ventilation, cranes and transport, electricity, gas, etc).

In time, these internal coordination means have taken over a number of tasks that were outside the strict mandate of the ST division (scheduling and general planning), with some reluctance some times from other divisions providing infrastructure efforts for the LHC experiments, but in a seemingly (in retrospect) successful way. Later, the activities carried out by these coordination means have been merged by the Technical Co-ordinations of the LHC experiments (to different extent in the different experiment) with their own planning, coordination and scheduling activities.

These past years also seem to show that a closer collaboration in the infrastructure field can facilitate the development of further opportunities (linked to the competence available in the groups of the Technical Sector) and of great interest to the experiments (like the participation of the design and construction of the detectors cooling systems, UPSs and secured power distribution or hazard detection for the protection of people or material, just to mention a few). The increase in the demand confirms the Technical Sector's support as a much appreciated help in this area, but should also push the Technical Sector to understand the dynamic environment of the experimental physics divisions and follow the evolution by adapting its structures.

It is the authors' belief that the synergies between project managers, personnel involved and group structures, brought forward by these coordination means, have strongly improved the quality of service in the specific divisional domains. However, it has appeared clearly over the whole process that the Technical Sector's structure is not adapted to the task. In view of this, some constructive criticism will be given, for academic purposes mainly, as the argument unfolds.

This paper will develop the ideas presented here, concluding by giving a picture of the last few months activity, mainly concentrated on the ATLAS and CMS experiments.

2 THE LHC EXPERIMENTS PERCEPTION OF THE INFRASTRUCTURE PROJECT

Perhaps it is of interest to the Technical Sector's general public to describe here very briefly the authors' perception from the experiment side of the "infrastructure project" (understood as the totality of items corresponding to expertise found in the EST and ST division, comprising infrastructure and Experimental area).

The LHC Experiments, in what regards the infrastructure, have seen a number of difficulties in past years in the definition of the funding necessary and available and to some extent the problem is not yet solved. The very last exercise to determine financial responsibilities (EVM) is under way and hopefully will see all loose ends tied up very soon, but in the meantime there has been much controversy on the funding of items which are felt as infrastructure by the experiments and which appear to be in no-man's-land. The downside of this clarification exercise is that the planning and scheduling of the infrastructure items has been much affected.

With the exception however of these borderline problems (which to this point have been resolved by the LHC project management mostly by assigning additional funding to the Technical Sector groups, and the technical responsibility with it), the LHC Experiments are genuinely grateful of the intervention done so far by the Technical Sector (both for the infrastructure items that are on CERN's budgets and those on the Collaborations budget). The Technical Sector needs to live up to the expectations.

3 THE TECHNICAL SUPPORT'S PERCEPTION

On their side, the authors have experienced in these past years the realisation, that the Technical Sector's general public may not have a full picture of how complex and interlinked the schedule for

the assembly of the experiment is, and how dependent the whole enterprise is on the correct execution (schedule, performance, envelopes and of course cost) of the infrastructure tasks (contracts).

The detector environment is much more organized, flexible and able to react quickly to difficult situations that the Technical sector may think or be used to itself. The scheduling activity is capital for the installation (just to give an idea, the total number of tasks declared in the master schedule is in excess of 2,000, of which just over 300 are infrastructure). Follow-up exercises are of major importance to flag out problems and search solutions and this requires the same pace from the technical sector if the schedule is to be kept coherent and meaningful.

The different infrastructure items are obviously needed for the installation of the experiment and therefore installed first of all. Any significant delay in these items have the highest importance as the very few months float in the whole of the experiment's schedule can be easily lost during the first stages. For that reason the Technical groups must be extremely vigilant in the performance of their work by industrial contractors.

4 EXTENDED COLLABORATION WITH THE TECHNICAL SECTOR

Form the early days of this collaboration, the experiments have requested, in very unambiguous terms, that ST increased its involvement in the activities related to the experimental area and infrastructure. Two basic reasons seemed to favour this initiative. The first one was the fact that there is already available at CERN the competence required to carry out the project in the respect of schedule and budget. The second reason was to entrust the project execution to the candidate "apparent" for the future phase of maintenance and operation.

Independent approaches to the Technical Sector's groups at first and, after some time, the LEAF meeting, have been channelling the requests for this increased collaboration, which have been detailed in a series of "service agreements" signed between the Experiments and the technical groups. Resources (human and financial) have been made available under the terms of the agreements. In most cases, all the necessary elements have been made available on the experiment's side for the work on the technical sector side to proceed.

5 A PRELIMINARY BALANCE

There is still much work to be done before a definitive assessment of the collaboration between the Experiments and the Technical Sector can be done. A preliminary balance can be drawn however at this stage, listing the main pros and cons below. It needs to be said here that the criticism presented here has for objective to flag out problems that in some cases are already being solved, again as result of the collaboration.

5.1 Pros:

- Better coordination (information between the groups involved) and the Experiments.
- An installation schedule has been established (for the first time and updated since) that covers the entirety of the Sector's activities.
- Installation problems were identified from the first versions and corrected. In some cases the interaction with the groups contractor's has been fast and effective.
- Traceability of process thanks to coordination meetings and minutes.
- Better view on infrastructure items for which funding was missing.
- Outlet found for items in which the Experiments have no expertise or adequate means. Many items agreed with Technical Sector since.

5.2 Cons:

- Groups' relationships with their contractors still very much black-boxes in which the Experiments (users and often payer) have little possible interaction. PPT (or other) reporting poorly or not employed.

- Different versions of groups' CtC very opaque, keeping the Experiments uninformed of what infrastructure items were not covered. EVM should bring an end to this problem.
- The technical groups have not been sufficiently proactive in proposing solutions for reporting and solving the problem of the missing funds for infrastructure items.
- Schedule perceived as a theoretical exercise. Only very recently have some groups started to follow it in a regular and critical manner.
- Some coordination problems perceived. These fall outside the ST coordination role and can only be treated by groups' hierarchy.

6 LAST YEAR'S ACTIVITY

6.1 ATLAS Experimental Area

The last year has seen a number of important developments in the ATLAS Experimental Site, not least of all the start of operation for the Site management team, from the ATLAS Technical Coordination.

This team successfully manages the coordination of the site via regular site meetings in which the work-packages documentation is continuously reviewed and updated. Much of the work scheduled for the surface buildings is completed (indeed most of the buildings have already been handed over to ATLAS and the fitting of equipment is to be finished in the coming two months) whereas the installation in the technical cavern USA15 is well into the first six months of installation.

At this stage the gas building (SGX1) is finished and available for the gas mixing equipment to start being installed in the coming months, the cryogenics building (SH1) has started the last phase with the installation of the He compressors and cryo piping to the underground, the off-loading building (SDX1) has in the past year been fitted with an access control, lift, crane, PX15 shaft services and their connections to CERN networks, whilst the electrical general services are well underway. In the short future (2003) the connections to the underground for cryogenics and gas piping, and the construction of the DAQ racks room will start. The ventilation building (SUX1) will be completed during the next months and the Control room building (SCX1) is finally on its way to completion to be handed over to the Technical coordination for use early in summer 2003.

The USA15 cavern, where the three-story structure is to be completed in spring, has already seen the completion of the primary cooling piping and the start of the secondary cooling plant and piping. The cooling plant for the detector and its services will be commissioned within the summer 2003 whilst the ventilation, cryogenics, gas piping will take place as from the summer this year. Other activities, rather linked to the detector (like magnet system and racks installation) will also start as early as July 2003.

Finally, the UX15 cavern is in the very latest phase of completion by the Civil Engineering, and it will be ready for the hand-over on April 15th, on schedule.

In addition to the infrastructure items, ATLAS has benefited from the assistance of the technical Sector in matters where the expertise already exists in the house. These items have been the subject of a series of documents with the groups, in which the required services are specified. This range the whole of the technical sector activity, and just as example, a few of these will be listed here:

- Exceptional transport of the detector components,
- Cooling units for the detectors (evaporative, low temperature monophasic, fluorocarbon based, etc.),
- UPSs and secured power distribution for the detectors and their services,
- Cabling of the detector,
- Muon detector "Big Wheel" supports,
- Sniffer project, etc.

6.2 CMS Infrastructure and LHC Experimental Area

One of the specific aspects of the CMS installation in point 5 concerns the schedule. Few years ago the technical coordination decided that the first test of the detector would have been in the surface. The main positive consequence of this choice was a complete separation between the detector assembly activity, which could continue with no interruptions in 2002, and the civil engineering work advancement, which delays have not affected the global planning so far.

Therefore, during the first semester, CMS could continue the assembly of the last Ferry's Wheels and End Caps. The installation of the magnet metallic structures and cable trays has followed at the end of this year.

The summer period was dedicated to the swivelling test of the inner vacuum tank for the coil. The test consisted in reproducing the mechanical load to check the stress and deformation of the metallic structure during the insertion of the coil in the external vacuum tank. The result was satisfactory: this 250 tons cylinder, 13 meter long and 6 m wide was inserted in the external vacuum tank cantilevered from the central wheel with a tolerance of sometimes less than 5 mm!

On the front of the general services, it is worth mentioning the completion of the SGX5 building on surface by the civil engineering, more than twelve months before the scheduled date. This fact made the installation of the ventilation system and all other equipment much less critical. Cooling and ventilation activity continued in SUX during all this year and is progressing as expected around the PM54. A temporary cooling and gas system will be installed soon inside the SX5 to allow 'slice test' of the CMS detector in parallel with completion of the surface assembly.

Underground the excavation of the US and UX cavern seems to progress very fast too. The completion date will be certainly respected and the general services will be able to start the installation works in the US cavern at the beginning of 2004 and in the UX cavern in July 2004 as foreseen. At that point a large effort of co-ordination will be required for the management of the particularly intense activity around the PM54, the US and the UX.

Concerning the detector cooling systems, the contract for the services on the yoke has been attributed and the technical specification for the cooling system in the US will be ready by June 2003. In the case of ECAL, the situation has been improved after the analysis of the results of the model 0' tests, which were encouraging with respect to stability of the temperature. In this domain, the Tracker cooling still remain to be completely defined, but some recent choices related the secondary loop will certainly allow the group to progress quickly in 2003.

7 CONCLUSION

Much has been done in the past years to improve the interaction between the Technical Sector and the Experiments. This has had a positive outcome from many points of view. In general terms, it can be said that both sides have gained from the experience and that the increased understanding of the project has allowed focusing the attention on successively higher levels of detail.



Figure 1: Swiveling of inner vacuum tank to vertical position in SX5