

SUCCESSFULLY MANAGING THE EXPERIMENTAL AREA OF A LARGE PHYSICS EXPERIMENT FROM CIVIL ENGINEERING TO THE FIRST BEAMS

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Abstract

The role of "Experimental Area Manager" supported by a well organized, charismatic and motivated team is absolutely essential for managing the huge effort needed for a multi-cultural, multi-disciplinary installation of cathedral-size underground caverns housing a billion dollar physics experiment. Between the years 2002 and 2008, we supervised and coordinated the ATLAS work site at LHC, from the end of the civil engineering to the first circulating beams, culminating with 240 workers on the site, 24 hours a day, 7 days a week, with activities taking place simultaneously on the surface, in the 60 m shafts and in the 100 m underground experimental cavern. We depict the activities preparation scheme (including tasks ranging from the installation of 280 ton cranes to super-delicate silicon detectors), the work-site organization method, the safety management that was a top priority throughout the whole project, and the open-communication strategy that required maintaining permanent public visits. The accumulation of experience enables us to summarize the critical success factors for a timely and successful completion of such a vast and complex project.

WHAT IS EXPERIMENTAL AREA MANAGEMENT?

The large collaborations established for the LHC multi-purpose experiments CMS and ATLAS had to be adapted throughout the life cycle of the experiments. In the case of ATLAS, on which we will focus the rest of this paper, the Technical Coordination team included mostly physicists during the "Letter of Intent" stage [1] and up to the "technical proposal" [2] stages (1990 – 1994). The team was then reinforced with a dedicated engineering team to face the challenges of the Technical Design stage and component manufacturing stage (1995 – 2002).

In parallel, a working group was set-up to conceive and design the huge experimental area with the corresponding infrastructure and services. Civil engineering works started in 1997 and ended in 2002: the ATLAS cavern was then delivered for installing the infrastructure and later the particle detectors.

When nearing the infrastructure installation stage, the Experimental Area Management (EAM) team started to work in parallel with the technical coordination team: its role was to coordinate the installation of the infrastructure and services up to the arrival of detector elements, and prepare the area for the installation of the experiment.

The EAM team was composed of one Experimental Area Manager, a deputy, a safety delegate and two work

site supervisors. The Experimental Area Manager defined and implemented methods to organize the smooth coordination of the work on site and convened a weekly meeting involving all the CERN active Work Package Specialists, the transport coordinator and the ATLAS Technical Coordination team. Ongoing activities were reviewed and future work packages were carefully planned. An action list was produced and was continuously monitored.

The EAM team progressively adapted its field coordination techniques from an "industrial type" environment to the less conventional "physics institute" context. The successful methods put in place were pursued for the installation of the detector components. This work site management role went on till the closing of the detector for the first LHC beams.

MANAGING THE COACTIVITY

Coordination of the contractors

The stage corresponding to the installation of the infrastructure and services was extremely intense. Extensive planning and coordination plus negotiation skills were required from the EAM team.



Figure 1: Installation of the large infrastructure components in the ATLAS cavern: cranes, 13 storey high metallic structures and huge ventilation ducts

The initial planning was optimized with an ideal sequence but had rapidly to adapt to reality: key elements such as elevators (the caverns are located about 100 m underground), overhead travelling cranes and ventilation systems faced serious delays, and caused major disturbances to many other planned activities.

Six weeks had been anticipated for the installation of four large air ducts in the vertical shaft leading directly to the main experimental cavern (see Fig. 1). It took in fact

four weeks to install just the first one. This duct had then to be totally dismantled because it was leaky! This immediately led to a conflict with the steel frame contractor who was planned to start working in the cavern at the bottom of the shaft. Night work unfortunately was not an option for the company that was late due to non compliance with Swiss work regulations...

The peak in activity was reached when 50 companies (including subcontractors) were working on the site simultaneously. A strict distribution of the three dimensional space was discussed, agreed and displayed on site. It was revised and renegotiated daily.

Organization of the vertical transports

Strict organization of vertical transport was one of the success factors for a smooth delivery, from the beginning till the end of the installation.



Figure 2: Lowering the 14m high and 240t End Cap Toroid magnet in the ATLAS shaft

As two elevators were installed to transport personnel from the surface to the experimental cavern, vertical transport of people was never a real problem.

In parallel, the means planned for the installation of the equipment underground were sufficient: 2 surface cranes plus 2 cavern overhead travelling cranes had been anticipated (see Fig. 2). Nevertheless, the late delivery of the cranes was problematic as it imposed the rental of the Civil Engineering crane which was expensive, and required the usage of diesel mobile cranes in the cavern as a compensatory measure.

When all cranes were finally operational, it took some time to stabilize the transport team with skilled personnel (6 persons in all). A transport coordinator joined the EAM team with the role to centralize and prioritize all transport requests. This task was particularly difficult as one cannot prevent direct contacts between the requesters and the crane drivers. To avoid conflicts, an early morning meeting was established to produce a daily list of transports which was displayed on a white board. The list was amended throughout the day.

The stage that followed the installation of the infrastructure also included serious coordination challenges. The culture of workers coming from physics institutes all over the world was a new parameter to

consider. It was a big surprise to realize that the near priceless ATLAS detector very often did not get the respect it deserved. Keeping the experimental area clean became an everyday challenge, imposed both by health and safety and the delicate nature of both the work and detector components.

MANAGING SAFETY

As work was spread over a large variety of heights (above ground, in the shafts, on the 12 storey high metallic structure and on the newly installed detector), and involved numerous sources of potential hazards (cryogenics, high and low voltage, large magnets etc.), safety remained the first priority throughout the whole installation process. The occurrence of a serious accident could have threatened the whole project.

Anticipating the risks through Work Package Analyses

Each company or group intending to work on the ATLAS site had to prepare a safety plan that was reviewed through a Work Package Analysis process. This consisted in a series of meetings where the Safety Coordinator together with the Experimental Area Manager checked the documentation and the working methods in order to ensure that they were safe, sound and adapted. This inevitably led to awkward discussions as the safety culture covers a wide range of different appreciations throughout the many countries involved in the ATLAS installation!

Dealing with work at height

Stringent rules were enforced concerning the wear of personal safety equipment (hard hat, safety shoes, torch light and harness). One member of the EAM team was trained to become a specialized instructor for work at height. Regular inspections of the specific equipment were organized, and its correct usage was carefully checked.

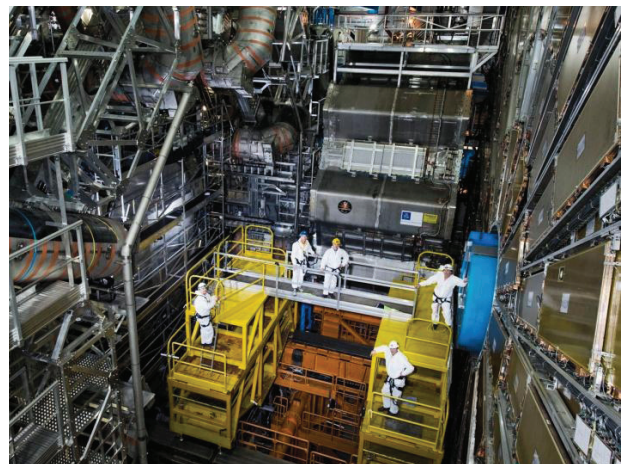


Figure 3: ATLAS Experimental Area Management Team in the ATLAS cavern

This non standard work site required its own safety rules: an adaptable safety perimeter at the bottom of the shaft during heavy handling had to be agreed: from 3 m around the footprint of the shaft, up to the evacuation of the complete cavern during the lowering of the largest detector components weighing up to 280 tons!

MANAGING COMMUNICATION AND VISITS

The small world of particle physics is nearly exclusively funded by public subsidies, and is also one of the most difficult fields of research to explain to the general public. We therefore considered it as an absolute must to maintain visits for locals, students, VIP's from funding agencies, and most of all, tax payers from all member states and beyond. As such, visits were, and still are, integrally part of CERN communication strategy.

The LHC worksite and in particular the construction of the ATLAS experimental area was an amazing sight to see for anyone, be they involved in techniques or not.

Being both the largest particle physics detector and so close to the CERN main site, ATLAS work site had the privilege to be at the top of the list of marvels to be seen at CERN! The sheer dimensions of the cavern associated with the incredible techniques gathered for the LHC project created a "wow factor" for everyone visiting the ATLAS experiment.

The organization of large numbers of visits (up to 30 000 visitors were recorded at ATLAS underground each year) imposed a strict organization. The safety of visitors and minimum disturbance to the progress of work were the main concerns.



Figure 4: Visitors marvelling at the wonders in the ATLAS cavern

The constant flow of visitors was also an incentive for the EAM team to make sure the site remained as tidy as possible and to illustrate the visit itinerary with posters and pictures.

The guides (from the CERN visit service as well as from the ATLAS collaboration) were specially trained for the specific environment by the EAM team. Even the CERN Director General Prof. R. Aymard was trained as an official ATLAS guide! The ATLAS secretariat kept the

agenda of visits, in close contact with the EAM team to adapt to conditions on the site. The visit itinerary was modified regularly to allow the continuation of visits, even in the most difficult periods of the work site installation, limiting groups to a small number of visitors or reducing time underground as necessary.

Visitors came from all parts of the world to see the civil engineering works or the delicate physics apparatus being installed, and only a few very minor incidents were recorded.

CONCLUSION

Having spent 6 years managing the ATLAS experiment work site, from the end of the civil engineering stage up to the circulation of the first beams in LHC, we can extrapolate the main success factors to be remembered for a safe Experimental Area Management of future similar work sites:

The first lesson learnt the hard way is that an underground worksite is nothing like an ordinary worksite: companies in their vast majority are not used to the specific constraints and particular difficulties of a real 3D environment. Therefore, all scheduling exercises have to be taken with the greatest care and contingencies must be adapted to the specific environment. However, the "learning curve" is spectacular.

The second lesson is that the safety management must be tailored to underground work conditions, taking into account that here again, most companies are in a very unfamiliar environment: the Work Package Analysis method proved well adapted to this context. Control on site must remain continuous and vigilant. This was one of the most difficult tasks of the EAM team, as no one in the team was ever trained to be a policeman... It was also important that the EAM team remained hierarchically independent from the project management as safety and planning constraints are often contradictory.

The third lesson is that keeping CERN or institute design engineers involved in the installation of equipment they have conceived makes the task much easier. This is unfortunately not always possible mainly due to the duration of such long projects: many engineers have already retired, left or changed orientation when the time of installation comes!

REFERENCES

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- [2] ATLAS Collaboration, "ATLAS Technical Proposal for a General-Purpose pp Experiment at the Large Hadron Collider at CERN", Geneva, 1994; <http://atlas.web.cern.ch/Atlas/TP/NEW/HTML/tp9new/tp9.html>