EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE

CERN - TS Department

EDMS Nr: 473742
Group reference: TS-LEA

TS-Note-2004-031
5 May 2004

MANAGING THE LHC EXPERIMENTAL AREAS

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Abstract

Following handover by the civil engineering contractors the new LHC experimental areas must be fitted-out with appropriate infrastructure and technical services. An installation schedule taking into account all the activities involved must be developed and kept up-to-date. Integration of this installation planning with that of the LHC Machine and detectors of the experiment are vital elements. Once installation starts an Experimental Area Management (EAM) team must be set up to co-ordinate all area activities. This process will be illustrated for the new areas at Point 1 and Point 5, and the EAM of the existing areas at Point 2 and 8, custom built and inherited from LEP, will also be compared. The status of installation in all areas will be briefly presented. The important tasks of EAM will be explained, and the organization used to achieve the goals will be detailed, with an emphasis on safety aspects. The successes and difficulties encountered so far will be reviewed and the conclusions that have been drawn from this experience will be discussed.

Presented at the TS Workshop
Archamps, France, May 4 – May 6, 2004

CMS EXPERIMENTAL AREA

1 INTRODUCTION

Point 5 is a fine example of how activities handled by the TS groups, the LHC machine groups and CMS have to be smoothly scheduled and coordinated to avoid conflicts. Because of the limited space and the high numbers of working teams concurrently operating on the site, a coordination planning needs to be developed. It includes activities ranging from power distribution to off detector gas system installation. The broad scope of this planning concerns the technical installation of point 5 and includes all the surface buildings, the tunnels and the caverns. To ensure its relevance and versatility this planning shares milestones with both the CMS and LHC planning. Reviewing and updating it on a regular basis provides an efficient tool to monitor progress and optimize task sequencing. To illustrate how this planning can have a decisive impact on the overall progress of the building of CMS, this article will focus on a short term critical path leading to the milestone “Ready for crates in the USC”.

2 PRESENT STATUS

The CMS site called point 5 has already been undergoing huge transformations in the last two years. To better picture the present status of the works, both the constructions on the surface and underground have to be reviewed.

2.1 Surface work

Up to ten buildings will eventually be built on the point 5 site. Figure 1 shows a three dimensional view of the site.

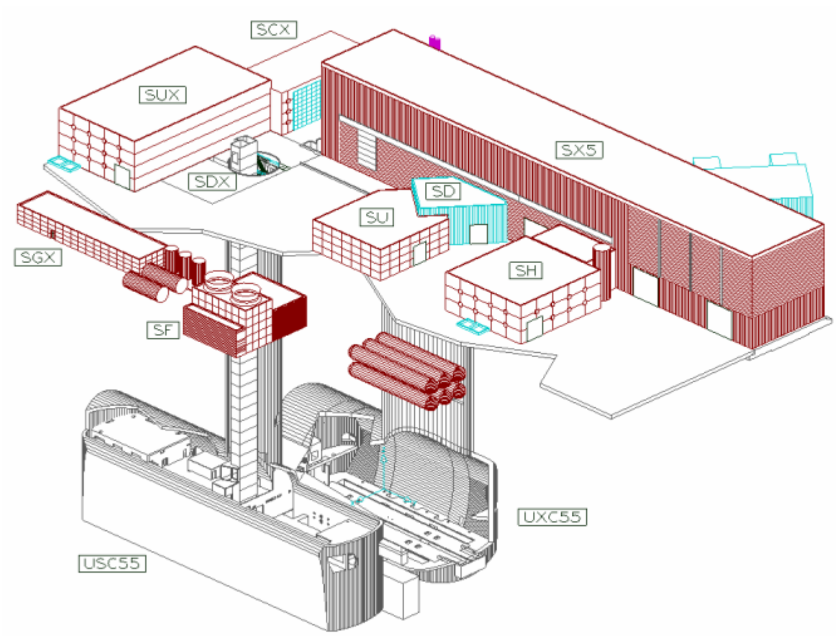

Fig. 1: Buildings, shafts, and caverns at point 5

If most buildings are already completed, three main construction activities still have to take place. The SCX building, hosting the control electronics for the experiment is currently being built. The handover from the civil engineering to CERN is planned for the beginning of 2005. From then on the technical installation will take approximately six months. As far as the SDX building is concerned, the foundation slab should be finished by the middle of July, allowing a ten week window dedicated to the lowering of material inside the USC cavern and the technical installation of the PM54 shaft. The assembly of the metallic structures making the skeleton of the SDX building will start upon completion of the ten week window. Finally, the length of the SX building will be expanded to cover the PX56 shaft and host the 2,000 ton gantry crane needed to lower the detector into the UXC.

2.2 Underground work

Most of the civil engineering work in the tunnels and caverns is close to completion. Both the USC55 and the PM54 are planned to be handed over to CERN during May 2004. Having access to the USC55 represents a major step forward for it will allow the TS groups to meet the first crucial CMS milestone "Ready for crates in the USC".

The UXC cavern and its shaft should be made available during September 2004. From this date on, the technical installation of the cavern will start.

3 MEETING THE "READY FOR CRATES IN THE USC" MILESTONE

On the critical path to the CMS installation, a significant achievement will be to have the DAQ and LHC crates installation started by July 15^{th} 2005. This deadline defined by CMS should allow sufficient time for the commissioning of the Data Acquisition system.

3.1 Activities in the PM54

Figure 2 shows the sequence of tasks running from the shaft and cavern delivery until the end of the ten week window.

Task Name	Owner	Duration	Contractor(s)
PM54 & USC55 Delivery	TS-CE	0 days	DRAGADOS
PM54 Installation		**20 days**	
Temporary ventilation USC+CE services removal	**TS-CE/CV**	1 wk	GESCO
Shaft protection plug on top of pit	**TS-CE**	1 wk	DRAGADOS
Temporary electricity	TS-EL	2 wks	HADRALEC
Installation of USC 10t platform (tremie)	TS-IC	2 wks	COSMI
Lowering and installation of material for USC55		**378 days**	
Lowering prior to 10-week window		**80 days**	
18-t Mobile Crane in USC55	TS-IC-LO	1 day	CICERON
10-t gantry crane + rail + 2 personnel hoists	TS-IC-LO	3 days	CICERON
Transfer lines for He	**AT-ECR**	5 days	AirLiquide
Metallic structures for USC55	TS-IC	77 days	COSMI
10-week window		**50 days**	
Lowering (done at night)		**50 days**	
Ventilation units and ducts	**TS-CV**	10 wks	GESCO
6-t transformers and other material	TS-EL	10 wks	HADRALEC
Copper bus bars + metallic structure	PH-CMI	2 days	TS-IC(HM)
Installation (done during daytime)		**50 days**	
Permanent Ventilation installation	**TS-CV**	22 days	GESCO
Concrete modules installation	TS-CE	17 days	ELEMENT
Penultimate module installation	TS-CE	0 days	ELEMENT
Ventilation inside the Concrete Modules	**TS-CV**	4 days	GESCO
Lift Machinery installation	TS-IC-HM	1 wk	AS service
Last module installation	TS-CE	1 day	ELEMENT
Closing the machinery roof	TS-CE	1 day	ELEMENT
Metallic staircase modules installation	TS-IC	4 wks	COSMI

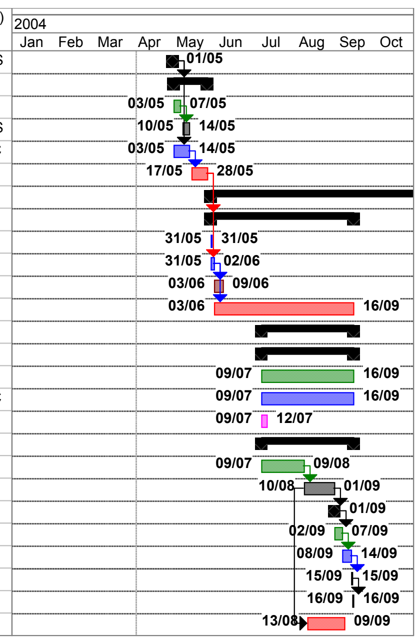

Fig. 2: Sequence of activities taking place in the PM54

3.2 Activities in the control area of the USC55 cavern

The control area is located on the end of the USC cavern by the gas room. A two level structure has to be built and installed to receive the racks that will eventually be filled up with the DAQ crates. By swapping the working teams between the two floors of the building, a significant amount of time could be saved. While the electricians will be installing the cable trays and the power distribution for the racks on one floor, a team will install the cooling pipes on the other floor. In addition to the time saved, such an arrangement allows keeping the electricity and water activities away from each other while progressing in parallel. Figure 3 shows the planning for this area.

Task Name	Owner	Duration	Contractor(s)
USC55 Control Area (Gas Room End)		**293 days**	
Metallic structures installation	TS-IC	10 wks	COSMI
Ventilation ducts for racks	TS-CV	18 wks	GESCO
General services	TS-EL	4 wks	HADRALEC
Power distribution for racks 1st Phase GndFloor	TS-EL	6 wks	HADRALEC
Cables tray installation GndFloor	TS-EL	3 wks	HADRALEC
Ready to install racks		0 days	
Racks Installation GndFloor	PH-CMI	5 wks	tbd
Power distribution for racks 2nd phase GndFloor	TS-EL	8 wks	HADRALEC
Power distribution for racks 1st Phase 1stFloor	TS-EL	6 wks	HADRALEC
Cables tray installation 1stFloor	TS-EL	3 wks	HADRALEC
Racks installation 1stFloor	PH-CMI	5 wks	tbd
Power distribution for racks 2nd phase 1stFloor	TS-EL	8 wks	HADRALEC
Cooling pipe installation	TS-CV	17 wks	tbd
Separation wall building	TS-CE/IC	4 wks	tbd
Ready for crates		0 wks	
CMS Deadline "Ready for crates"		0 days	

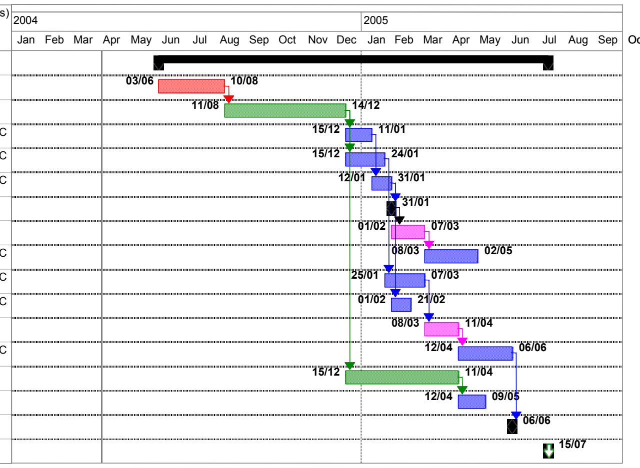

Fig. 3: Sequence of activities taking place in the Control Area of the USC55

ATLAS EXPERIMENTAL AREA

4 INTRODUCTION

The ATLAS experimental area is presently under installation at LHC Point 1, constituting one of the biggest work-sites at CERN. All surface buildings and underground caverns have been delivered to the TS department, and huge infrastructure installation works are already achieved. In parallel with infrastructure work, both experimental and technical caverns have started to be occupied by detector equipment.

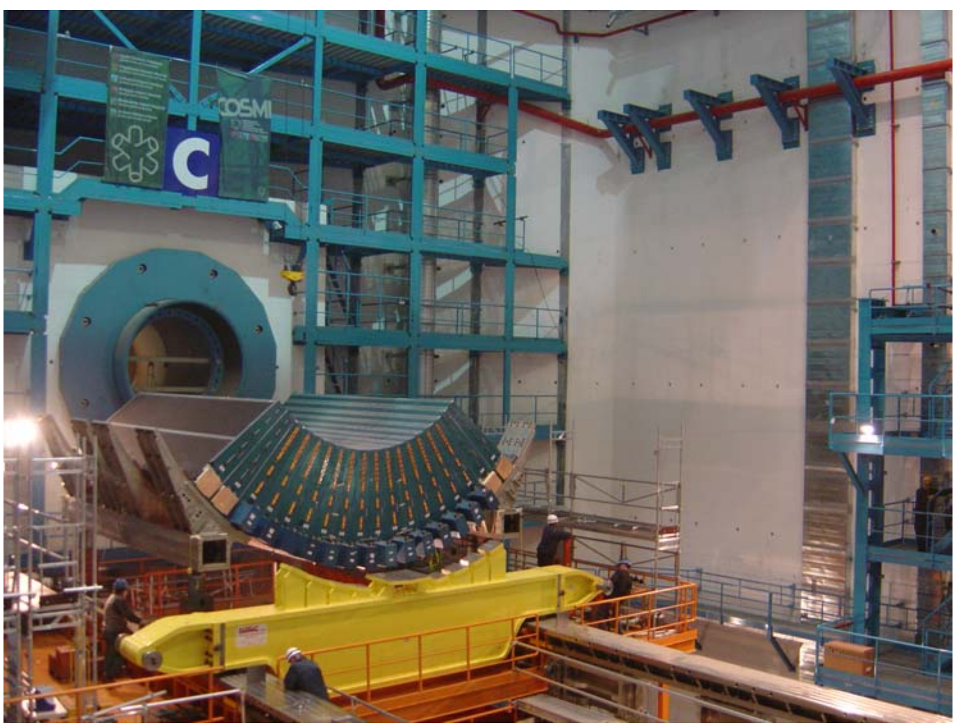

Fig 5: The ATLAS Tile Calorimeter in the UX15 cavern

5 STATUS OF INSTALLATION

The installation in all surface buildings is nearing completion: all specialized buildings (gas, helium compressors, ventilation) have entered the commissioning stage, while the general usage buildings (SDX1, SX1) are being fitted with last features (smoke detection) but are already functional, with the largest cranes of CERN being operational there. The SCX1 building -the future ATLAS control room-has been transferred to the end user, and is occupied by the ATLAS technical coordination.

In the underground areas, very major infrastructure installation works have been completed both in the technical cavern (USA15) and experimental cavern (UX15):

- About 1000 tons of metallic structure providing access up to 35 m high
- 160 tons of radiation shielding
- 8 new cranes are operational (including surface cranes)
- 3 new lifts are installed, out of which 2 will enable easier vertical circulation through the 13 storey frame of UX15
- kilometers of water pipes, gas pipes, cryogenic lines
- 1 cryogenic plant and 1 cooling plant in USA15
- hundreds of meters of ventilation ducts
- 1 electrical sub-station and general services in USA15

In parallel, and in order to make up for too short time available, the installation of the detector has already started in the UX15 experimental cavern, beside the infrastructure equipment installation: the main feet and rails that will support the 8000 tons of the ATLAS detector are already installed and waiting for the lowering of the toroid barrel coils. The barrel part of the Tile Calorimeter is being re-assembled in UX15, and will be ready to receive the liquid argon barrel calorimeter that will be lowered in September 04.

In the USA15 technical cavern, the electronics racks for the detector are already being installed in large numbers, in parallel with the magnet bus bars.

6 EAM WORK ORGANISATION

In order to plan, schedule and organize the work on the site, in the extremely complex and dangerous environment, the Experimental Area Management team has started its coordination work since October 2002. The team is composed of 7 persons from the TS department and from the ATLAS technical coordination. The management tasks are organized through 3 different regular meetings:

- The weekly Experimental Area Management meeting, where we summarize the past week, anticipate the coming week (safety, transports, work zones attribution, share of resources), and review the action list.
- The Work Package Analysis meeting held monthly or more frequently when needed, where we analyze the work method of the WP to come in month M+1, review documentation (PPSPS, WP, schedule etc), define needs (space, access, transports, power, fluids) and analyse co-activity issues.
- Two weekly scheduling meetings, one devoted to schedule TS installation work only, and one to integrate TS activities with ATLAS installation activities. This is where the re-scheduling is performed when changes or delays occur.

In parallel to this team, the ATLAS technical coordination organizes its own structure to plan the work for the installation of the detectors and sub-detectors. All schedules are gathered by the ATLAS planning officer, who is also part of the EAM team.

7 EAM ISSUES

7.1 Main difficulties encountered

The difficulties in the installation of the infrastructure equipment started end 2002: major delays were first encountered for the availability of the main elevator providing access to underground. Then the USA15 hoist that had been planned to be used for the metallic frame installation in USA15 came with 2 months delays, causing problematic installation method changes.

Since then, most difficulties on site are linked to recurrent problems with newly installed (and fairly complicate) cranes. This has caused delays on the installation of other equipment, and then as a cascade effect, major disturbances in the management of the co-activities.

The other source of difficulties came from the poor organization of the cooling and ventilation contractor, who found it hard to install material up to the required standard, using convincingly safe methods. This resulted in a number of potentially hazardous situations, when the work had to be stopped until safer methods were found.

While it is easy to deal with minor delays, of the order of one week, the consequent delays of several months in the ventilation equipment installation, combined with the nature and size of the work (huge ducts to be installed all around the vault of the cavern, 30 m above the cavern floor) lead to extremely difficult co-activity situations and avoid super-imposition of tasks. At certain points, in order not to cause even more problematic and costly delays in other installation contracts, the work coordination and supervision had to be adapted hour by hour, making usage of all the possible resources!

The update of the schedule is a heavy task, and EAM has lacked and is still lacking a dedicated planning officer for infrastructure work.

7.2 What we learnt from these

Apart from the obvious ones (intelligent planning, incorporating margins etc), the essential points to avoid difficult situations are at 3 levels:

- A thorough investment of the CERN project engineers in the pre-work phase of the contract, with frequent contacts with the company is essential to ensure that the material that has been ordered will be of the required quality and available on schedule. And every time it is possible, the project engineers who are the ones who know the design, should continue to be involved in the on-site installation.
- The role of the CERN work supervisors cannot be overstated, and their presence on the site as correspondents for EAM and other work supervisors is required on a daily basis, and continuously in critical periods, such as work start, difficult operation or close co-activity.
- Constant presence of the EAM on site, acting in partnership with the safety coordinators, so as to always make safety prevail over planning constraints. It must always be kept in mind that it is largely preferable to stop the work if a dangerous situation is considered as imminent than have the work stopped by work inspectors or worse by an accident.

8 SAFETY MANAGEMENT

Particular attention is given to all safety aspects in the work of the EAM:

One member of EAM team is dedicated for enforcement of safety rules and usage of collective and individual protection means.

As stated above the role of the safety coordinator is essential, and they are considered as important partners in the planning of the tasks and in the analysis of WP. In practical, the GLIMOS and the safety coordinators perform jointly a weekly inspection of the area, the output of which is treated in weekly EAM meetings, and corresponding actions are taken immediately.

Boards have been installed in all buildings and cavern to display the safety documents of all contractors, and it is frequent that EAM members refer to these to check the working methods.

So far, since the end of civil engineering works, more than 100 work packages have been handled. Still today, about 50 contractors work on the ATLAS experimental area, mostly satisfactorily, with no serious accident so far, and ATLAS detector installation underground was able to start according to schedule.

ALICE EXPERIMENTAL AREA

Like LHCb, the Alice experiment is distinguishable from CMS and ATLAS by re-using an existing LEP experimental area.

9 THE EAM TEAM AT POINT 2.

The EAM team is in charge of preparing the available infrastructure at point 2 in order to match it as much as possible the new requirements of the Alice experiment and in some cases, new facilities must be implemented.

TS-LEA took the keys from the L3 team in June 2001 and completed the dismantling of the former experiment. The main modifications at point 2 consisted of:

Civil engineering: a new 500 m^3 pit has been dug in the SXL2 floor for the pre-commissioning of detectors, covered by a clean room devoted to the TPC assembly. The gallery between US and UX 25, the Alice control room in SX2 building and the Dipole magnet foundation are the other changes.

Heavy handling: two overhead cranes (1 x 2 t, 2 x 20 t) and a 3 t capacity hoist system have been set up.

Cooling and ventilation: two additional heat exchangers and new pumps have been integrated in US 25 plant in order to increase the cooling capacity for the L3 and dipole magnets.

In addition, the gas building has been fully refurbished and the Dipole magnet power supply is now ready to run. Brand new gangways and staircases are fitting the UX25 experimental pit according to the Alice layout.

These modifications have been carried out using as much as possible existing contracts. However, for the major ones, IT procedures were launched and closely monitored by the EAM team in collaboration with each of the main service groups involved.

10 THE ALICE INSTALLATION TEAM AT POINT 2.

Because the hardware infrastructure is already available at point 2 (magnets, cooling and power supply facilities), the detector construction and pre-commissioning phase is currently well in progress. Therefore, an Alice installation team already exists and gathers people coming from various institutes of the Alice world-wide collaboration (Russia, China, ...). The mandate of TS-LEA is up to now adjusted to this situation. The Alice installation team and EAM team are so closely connected that they act in fact as one.

The L3 magnet modifications, the Dipole magnet construction, the detector support structures (space frame, baby space frame), the absorber and front absorber assembly are the main TS-LEA contributions to the Alice experiment.

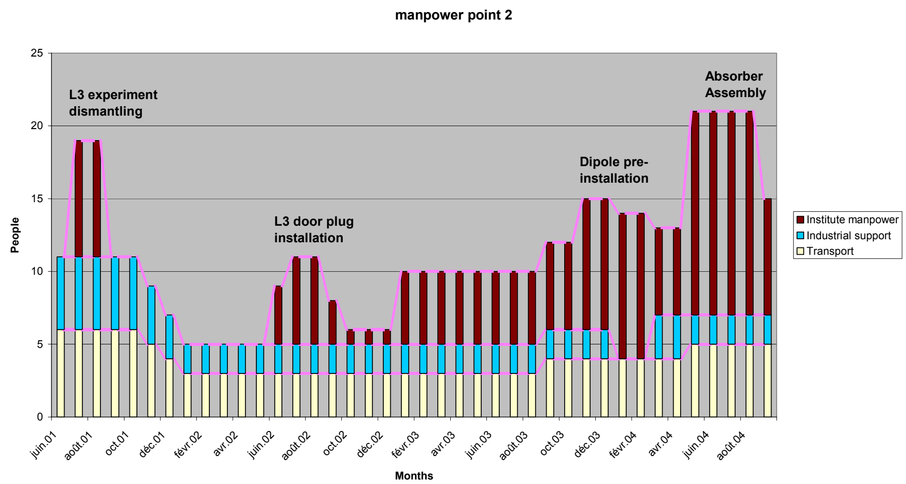

Fig. 4: Alice installation team manpower evolution (CERN staff excluded)

11 MANAGEMENT TOOLS

Two kinds of meeting are held. Every two weeks, the coordination of all TS groups involved at point 2 is achieved in the so-called "Instal meeting". In addition, a weekly worksite meeting is held every Friday morning in order to organize the daily work at point 2.

A job request form has been created for collecting all relevant information related to a task assigned to the Alice installation team: job description, budget code, schedule, allocated manpower, orders, equipments, safety issues, follow-up and feedback are given at first sight.

The schedule is also weekly discussed and updated by TS-LEA-ALI section.

The main difficulties in managing the Point 2 experimental area and Alice installation activities have been identified. Although work performed in sequence is the target to reach, due to limited resources and infrastructure facilities (crane, space, etc.) and time constraints, work is sometimes carried out in parallel. This implies extra costs and keeping a high level of safety is more difficult. To avoid or reduce this kind of situation remains the EAM team challenge.