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# A PLANNING AND SCHEDULING SYSTEM FOR THE ESS ACCELERATOR PROJECT

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*Abstract*

Constructing a large, international research infrastructure is a complex task, especially when a large fraction of the equipment is delivered as in-kind contributions. A mature project management approach is essential to lead the planning and construction to deliver scientifically and technically.

The purpose of this paper is to present how the ESS accelerator project is managed in terms of planning and scheduling from the design phase until commissioning, keeping time, budgets and resources constraints, as well as creating and maintaining a strong and trust-based partnership with the external contributors.

## INTRODUCTION

The European Spallation Source (ESS) is one of the largest science and technology infrastructure projects being built today. Bringing into successful operation this complex 1.8 billion-euro accelerator-based facility for neutron science implies collaborations among national institutions and nations. As a result, completing ESS, technically, financially and within schedule is strongly dependent from the capability of all the participants to meet delivery and performance specifications. In such a context of a complex project spanning over many years, a centralised project management team has been created in order to support the planning and scheduling activities of each macro project, such as the ESS Accelerator ones [1].

## THE ESS CONSTRUCION PHASE

The ESS facility is currently under construction in Lund (Sweden). At present, the construction schedule is driven by the goals of producing neutrons by the end of 2019, completing the installation of the facility by the end of 2022 and installing/commissioning the neutron scattering instruments by the end of 2025.

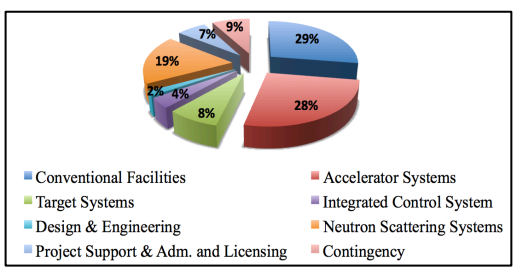


Figure 1: Distribution of the construction budget in % for the ESS macro-projects. The 510 million-euro accelerator project is shown in red.

The ESS construction phase is managed through seven macro project coordination schedules linked together. Five of the seven plans are machine and technically oriented, one is for tracking the civil engineering works, while two are used for administrative support (see Fig. 1). A centralized network-based is used for scheduling i.e. the Oracle's Primavera P6 software.

## THE ESS ACCELERATOR PLAN

The ESS accelerator plan is a delivery oriented plan and an integrated cost-loaded multi-year and multi-level schedule. It covers from the start of the preliminary design of the accelerator components (2013) until the capability of delivering 2 GeV protons on Target (2022). It includes the design and industry preparation stages of the different accelerator systems, the development of the prototypes, the series production, the installation in gallery and tunnel buildings and the cold and beam commissioning of the ESS linac. The general services as well as the test stands for RF and cryomodules are also included in the accelerator budget and resource constraints of the schedule. The purpose of the plan is to give a complete and up-to-date picture of the whole Accelerator Project, including tracking the external partners contribution works.

### *The WBS of the ESS Accelerator Plan*

A common Work Breakdown Structure (WBS) architecture is applied to all ESS projects during the construction phase. Work consists of activities and milestones, organized in a hierarchal structure (see Table 1). The WBS and levels do not necessary map in a one-to-one way the other breakdown structures, such as the ESS Product Breakdown Structure (PBS) of systems, sub-systems and components or the ESS Organizational Breakdown Structure (OBS).

Table 1: ESS Common WBS

| WBS level | WBS element |
|---|---|
| 1 | ESS Programme |
| 2 | Projects |
| 3 | Work Packages (WP) |
| 4 | Work Unit (WU) |
| 5 | Activities/Milestones |

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In-line with ESS guidelines, the accelerator schedule is divided into seventeen Work Packages (WP), of which two are related to management and coordination. Each WP has a well-defined scope and it is assigned to a WP leader, who is responsible for developing and executing the WP plan. On the top of the schedule the major key milestones and delivery dates from the different WPs are grouped and organized in a descending order of importance, depending on the consequences of missing completion dates. Milestones related to accelerator interactions/interfaces with other ESS Projects are also reported on the top of the schedule.

Budgets and resources assigned to each WP are not equally distributed, but depend upon the WP's technical scope and specific performances. As a consequence, the number of activities and milestones per WP is different. A detailed description of each WP's scope can be found in [2]. At present, the cost loaded activities (67%) and milestones (33%) are about 3000, organized in 100 Work Unit (WU). The cost-loaded tasks grouped per WU or sub-WU are/were used as cost reference for investigating possible partnerships [3].

### *Multi-level Approach*

A complex project spanning over many years calls for a strong coordination, crucial in particular when managing in-kind contributors from different country. Opting for multi-level planning for the ESS accelerator allows to simplify the communications between partners, to stay focused on common main objectives and it is more efficient in terms of project staff involvement. The top level is the High Level Master Schedule, below the WP Level Master Schedule and the Detailed WP Plan. They are all prepared by planning coordinators, verified and approved by accelerator management.

- The ***High Level Master Schedule*** covers the whole duration of the project and reviews the strategic goals and major milestones. Moreover, it gives a schematic presentation of the main dates per fields of technical challenges, such as the normal conducting part of the ESS accelerator, the super-conducting cryomodules and cavities, the radio-frequency systems and the cryogenics plant. It also shows the major design steps and the installation and commissioning windows. It is generally used for communicating progress outside the project team.
- The ***WP Level Master Schedule*** is based on the WBS and activities list of the official P6 Schedule. The aim is to visualise in a common way the project stages and main goals of the different WPs technical oriented in one sheet. It helps to highlight the time slots dedicated to design and industry preparation, procurement and manufacturing, installation and commissioning for equipment, systems or accelerator areas in the different WPs. It helps the coordination between them, showing the delivery dates and major constraints or boundary conditions. It has to respect the major milestones of the High Level Master Schedule and it underlines prototyping development stages and decisions based on research and development (R&D) progress, when applicable.
- The ***Detailed Schedule*** is at the lower level and contains all the detailed tasks. The scope of this schedule is to determinate all the resources required to achieve the task goals and to verify that the work can be completed in the time slot allocated. At present, this schedule is updated every month, since the ESS accelerator project is finalizing the detail design and procurement strategies of the major components.

### *Staff Plan*

The recruitment strategy for the accelerator project is based on the schedule and cost constraints and on specific need of technical/scientific competences to complete the planned tasks. The labour cost is calculated allocating 1800 hours per person per year, and fixed cost per hour, depending on the resource identified role. Once approved by the accelerator project manager, the WPs are aligned to the official staff plan (which includes also temporary consultants) through a resource levelling exercise.

### *Procurement Plan*

The major contracts (i.e. over 200 kEUR) are identified in the schedule for each WP by using a standardized template. It allows verifying that all the procurement steps are followed within the correct timeframe. The ESS Procurement Division for coordinating legal supporting activities uses the plan as reference.

### *In-kind Collaboration Plan*

The in-kind collaborators contribute to the ESS accelerators by delivering principally equipment and system, rather than contributing in cash. This implies a strong centralized ESS support. Consequently, the integration of the work provided by the partners in the schedule has to be sufficiently detailed in order to react quickly in case of problems, but also flexible enough to guarantee an appropriate level of freedom in organizing their work in their home institutes. Actually 50% of the total budget is identified in the accelerator schedule as *planned* in-kind activities. *Planned* means that laboratories or universities or organizations are identified and the process of formalizing the collaboration via an agreement contract is on going. The present accelerator schedule also includes areas of potentially additional contributions that should to be investigated in details. These activities are tagged as *possible* (see Fig. 2).

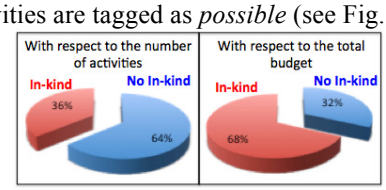


Figure 2: Present % of the (*planned* plus *possible*) in-kind contribution in the accelerator schedule. Additional areas related to the installation works are in course of investigation to increase the in-kind contribution for the accelerator project from 68% up to 75%.

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### *Installation Plan*

The chief engineer, in close collaboration with the system engineer and the head planner, develops the installation and commissioning plan for the accelerator project. He is also responsible for the technical design, the technical installation sequence and leads the integration group. The aim of the integrate installation schedule is to co-ordinate the teams and the installation activities in the space constraints of the ESS linac tunnel and gallery, with respect to the ESS safety rules.

From the point of view of scheduling, the integrated installation schedule requires a different WBS from the ESS formal ones (see Table 1 as reference). Indeed, in order to properly follow the progress and to keep optimizing the usage of resources, it is useful to have the tasks organized in a hierarchical structure of areas occupied in the accelerator buildings during installation and commissioning. Tunnel, gallery and stubs (between tunnel and gallery) are at the top of the WBS. Below, slices of the linac tunnel with respect to the accelerator equipment layout are used as reference [4], while areas identified by the civil engineering works are considered for gallery and stubs [5].

The installation plan is linked to the main accelerator schedule through Ready-For-Installation (RFI) milestone dates for the major accelerator components or through the start of macro installation activities that include more teams or equipment. Note that the RFI dates have not the same meaning as "installation date". Indeed, some equipment could require storage before bringing them to their final destination. This implies that the installation plan is also a reference for managing logistic constraints.

The budget for the installation work is quoted and tracked in the main accelerator schedule, while the installation schedule is used to identify the need of the appropriate competences to cover specific works in a well-defined area and to assure a continuous work-flow of the different teams involved. This approach allows to estimate a more realistic budget for installation and to reduce the risk of big deviation in budget [6].

## PLANNING PERFORMANCE MEASUREMENTS AND CHANGES

The Earned Value Management (EVM) methodology is used to monitor the performances of all ESS projects. Actual costs come from invoices stored in the ESS centralized financial system and from HR time reports for information on total worked hours per project roles. Every month, internal and external in-kind progress reports are used for updating earned figures. These data are compared to the schedule planned values. Explanations for possible deviations are reported to the ESS management as well as consequences and corrective actions, if needed.

In case of changes, a different approach is applied with respect to the approving authority required [7]. Summarising, minor changes within the same WP and without any consequence outside the WP itself is tracked and accepted rapidly. On the other hand, major changes require a more formal approach by documenting the reason of the rescheduling proposed, the solution retained and the impact on cost, schedule and performance. The highest level of approval is the Change Control Board (CCB), chaired by the ESS Director. If proposed changes are approved, a new baseline is released. In order to reduce the risks of (technical) scope creep, design reviews, test readiness and acceptance reviews are already at this stage identified in the whole lifecycle of the accelerator project.

## CONCLUSION

The planning and scheduling aproach described in this paper for the accelerator project is a dynamic process, which involves different stakeholders inside ESS and ones spread in different countries. In details, the schedule is developed with a rolling up approach and WBS adapted to the different need in the different stage of the accelerator project. The cost estimate does not include contingency, overhead, or escalation and the schedule is based on a "just in time" scheme. Some centralized guidelines are followed in particular in the field of planning control, but the complexity of the accelerator project has required developing specific tools in order to stay reactive and pro-active to the actual and future progress/changes. Due to the high involvement of in-kind partners (up to 75% in budget), the key to success is to bridge the institutional differences and help breakdown communications among the collaborators via an up-to-date and high quality accelerator schedule in the ESS construction phase.

## ACKNOWLEDGMENT

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