Case Study
Primavera High Quality Schedules for the ITER Fusion International Project

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"The European Joint Undertaking for ITER and the Development of Fusion Energy" (also known as "Fusion for Energy" - F4E) is a European Agency created under the Euratom Treaty by a decision of the Council of the European Union with the main objective of providing the European contribution to the ITER international fusion energy project.

A main challenge of F4E is the development of high quality and homogeneous schedules related to this EU in-kind procurement. This implies a significant effort in terms of schedule development, consolidation and integration, coordinated with the other ITER parties: China, India, Japan, Korea, Russia and USA.

F4E lessons learnt in terms of schedule quality and integration are described with Oracle Primavera P6 being the key tool for the optimization of EU schedules in the ITER context.

1. Introduction

ITER is an international project aiming to build a fusion experimental reactor in Cadarache, France. The project involves seven parties: China (CN), the European Union (EU, including Switzerland), India (IN), Japan (JA), the Republic of Korea (KO), the Russian Federation (RF) and The United States of America (US), which will provide "in kind" contribution to the central ITER International Organization (IO) to build the machine and all the buildings and auxiliary systems. Each of the seven parties is represented by a Domestic Agency (DA). The European one is the European Joint Undertaking for ITER and the Development of Fusion Energy or 'Fusion for Energy' (F4E) created under the Euratom Treaty by a decision of the Council of the European Union.

The development of the European Procurement Schedule for ITER follows a lifecycle with different phases characterized by the needs of the project. During these phases the schedules evolve to fit the project needs in order to use them as one of the key project management tools. This paper takes into consideration the schedules related to the procurement packages assigned to EU DA. Particular attention is granted to specific integration aspects of the various schedule lifecycle phases.

2. ITER and the project schedule challenges

ITER is the essential Next Step in the development of fusion energy with the main objective to demonstrate the scientific and technological feasibility of fusion power. ITER is based on a plan of 10 years construction and 15 years operation being part of a global fast track strategy for making available, after demonstration and prototypical reactors, fusion power plants electricity in the commercial net. Fusion power is unanimously recognized to be part of the energy solution, i.e., being an inexhaustible source of energy for the benefit of mankind.

The challenges for ITER in terms of planning & scheduling are multiple.

The ITER fabrication phase is 10 years long and requires a project oriented approach that is capable to keep the necessary efficiency under the constraint of involving multiple parties. The technologies involved in this project are not standard and need now an industrial support after many years of R&D activities carried out mostly at national research laboratory level.

The project is intrinsically technically complex (typically one order of magnitude higher than a modern commercial jet plane in terms of number of total items), multi-connected and highly integrated. Moreover ITER fulfills the stringent requirements for a nuclear safety relevant facility and equipment.

Each partner contributes by procuring in-kind the assigned part. The top level systems are structured in procurement packages which, in many cases, involve more than one party. Each involved party prepares one so-called Detailed WBS Schedule (DWS) per each procurement package. Each DWS encompasses at least one Procurement Agreement (PA, the formal contractual basis between IO and the single DA) and each PA can trigger several procurement/fabrication/service contracts placed by the single DA (procuring in-kind).

Each DA agrees with IO on a DWS at PA level, updating and declaring progress on a monthly basis. All of the DA and IO schedules are developed homogenously and according to high quality standards for global schedule integration purpose.

EU provides about the 45% of the nominal construction costs, while the other parties have each been assigned the same nominal percentage of the remaining share. The budget of the EU contribution to ITER construction is 6.6 billion euro (about 8.3 billion USD) in 2008 value. Therefore, EU clearly plays a primary role in the ITER project.

3. Primavera, Reference P&S Tool

Primavera Project Management software (now formally Oracle Primavera Project Management, i.e., Primavera P6) is the reference planning & scheduling tool for the ITER project and therefore is used by all DAs, including F4E.

Primavera P6 is also a key tool of the F4E Integrated Project Management System. This system is being developed to include applications for scope definition, financial & budget management, and contract management under a single data warehouse structure to be used for centralized reporting. At F4E, Primavera P6 database is the single source of truth for schedule data used in senior management and stakeholders' high level documents.

4. ITER Project Schedule

The structure of the ITER project schedule comprises the primary elements and the related targeted users shown in Figure 1.

<u>In order to allow a better understanding of the whole Primavera structure in the ITER project, the following definitions are provided.</u>

<u>DWS:</u> the set of Detailed WBS Schedules by the DAs and the IO - containing the activities, milestones and interfaces encompassing the full scope of the project and supporting the strategic management plan (SMP). Integration of the full set of DWS is automatic (via a dedicated Primavera API routine), using identified and validated schedule interfaces (the ICT, Interface Correspondence Table). The set of DWS is used:

- as unique source for project schedule data. Each DWS is developed by a single DA (or IO), but it is the unique reference for all involved DA's & IO technical responsible officers for the activities to be carried out;
- as "supplier" schedule from DAs against the "customer" IO;
- for managing interfaces and analyzing critical and near critical path activities;
- for resource loading IO activities;
- for detailed what-if schedule analyses and recovery planning;

- for event risk analysis;
- for schedule meetings and project performance analysis.

SMP: the Strategic Management Plan - the time phased baseline strategic plan with baselined key milestones for both DAs and IO, establishing the boundary conditions of the project. The SMP is rolled up from DWS and assists in the project decision-making process, for evaluation and re-prioritization of critical deliverables that require actions. SMP is milestone driven. Status SMP is regenerated at every schedule submission cycle by updating the dates of the common milestones with DWS data (the SMT, Strategic Milestone Table) and by recalculating duration of summary bars according to the milestone dates. Rolling up of DWS for obtaining SMP is automatic (via a Primavera API routine). SMP is implemented with high level logics with the purpose of executing quick trend analyses, live during Senior Management meetings.

OPS: the Overall Project Summary - reflects the ITER critical path, strategically important near critical path activities and significant major milestones. The OPS is used to communicate with stakeholders not directly involved with the execution of work, about the timing of major project phases, milestones, critical and near critical paths. The OPS is based only on the highest level of configuration baseline milestones. Typically, this is the schedule summary that is monitored by the ITER Council.

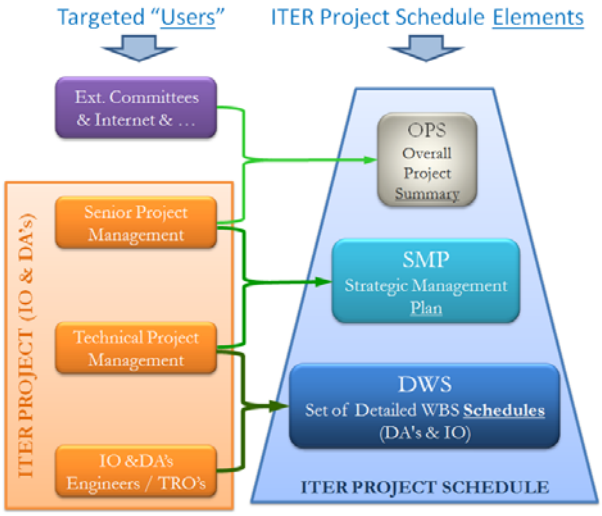

Figure 1: Main elements and related users of the ITER Project Schedule elements

The common data/interfaces tying the DWS, SMP and OPS elements, represented in Figure 2, are the SMT and ICT:

- SMT the Strategic Milestone Table contains the common milestones between the DWS and the SMP for baseline control. SMT is composed specifically by the configuration baseline milestones (CBM) and the major project milestones (MPM). Both are baselined.
- ICT the Interface Correspondence Table contains the pairs of Inter-Project Links (IPLs) defining each single schedule interface between the individual DWS (single DA's and IO Primavera projects) for the purpose of project integration and analysis of interface violations for baseline control and reporting.

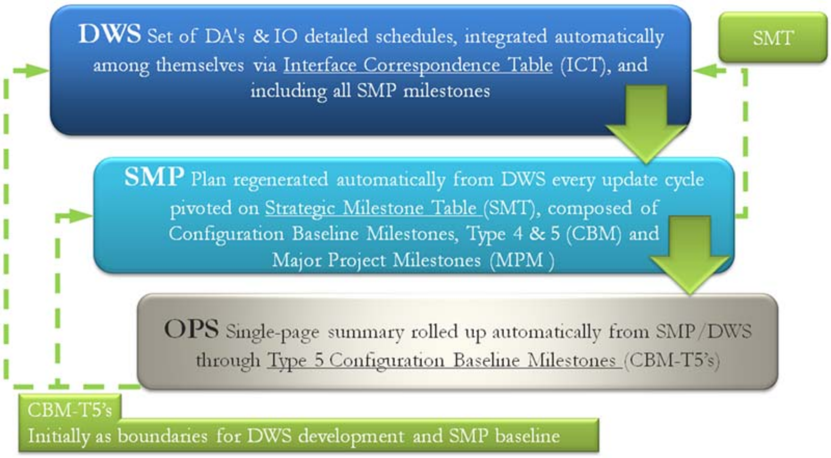

Figure 2: Dependencies among ITER Project Schedule elements

5. Development and approval of EU Schedules

The EU procurement schedules (DWS) follow an evolution synchronized with the project lifecycle from the moment they are conceived (see Figure 3).

During the development phase of the schedule, its input is fed from industrial studies and experts' know-how, as well as from ITER-specific gained planning knowledge. The latter is acquired by repetitively carrying out the steps in this phase for components which are similar from a project management point of view. The planning is then studied and defined using this information, which results in the lowest level of detail in the schedule lifetime.

The next phase represents the planning phase, with an evolution to represent the formal procurement relationship with IO by means of a Procurement Arrangement (PA). At this point in time, inputs from IO and F4E include both technical and legal aspects, assure technical competences, a monitoring plan and the global integration within the overall ITER project. The information concerning the ITER credit (acknowledged by ITER IO upon completion of in-kind procurement milestones) acquired by F4E while performing the work is also added in the form of agreed milestones.

During the execution phase, F4E starts its interaction with its own suppliers, which will execute the work as agreed with IO. At this stage, the F4E-managed schedule will include both the project control parameters to interface with IO and those for its relationship with the supplier. The inputs used for the definition of the schedule during the execution phase are provided by the Technical Responsible Officers from IO and F4E, by the monitoring plan applied to the supplier and by the contractual control plan.

During the three phases described above, the schedule evolves in its content in terms of maturity, granularity, interface and technical information.

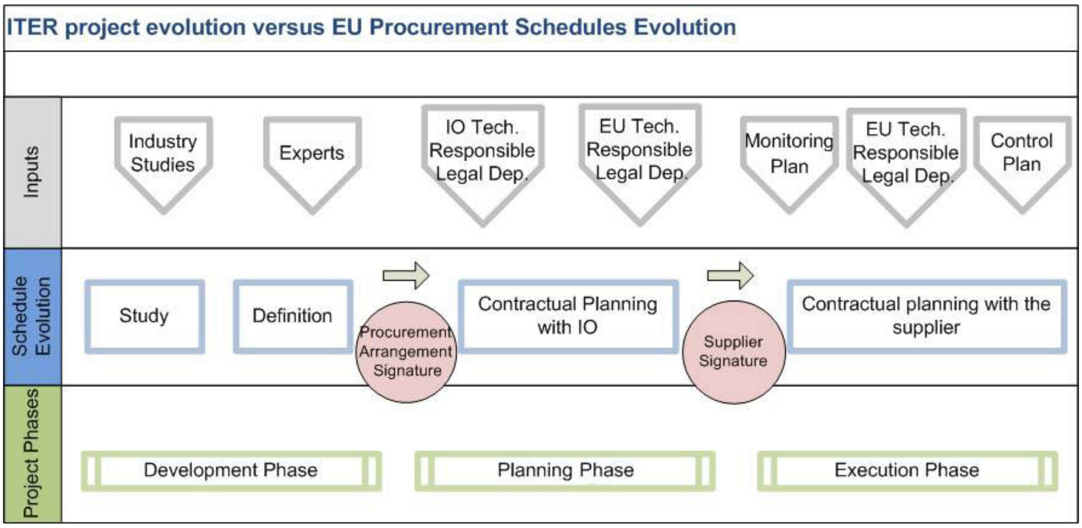

Figure 3: Project Schedule Lifecycle

6. High-Quality EU Detailed Schedules

The EU has identified a number of potentially negatively factors impacting schedule quality. The first factor is due to the nature of the ITER project (multi-party, in-kind based with a multi packages procurement scheme). A second factor is that detailed schedules are being developed at a time when a number of design features are still not fully identified. Due to the experimental nature of the ITER project, design reviews of various components and systems are continuously progressing. A design is still subject to change at any time until the final is formally approved and frozen by ITER IO.

Since the F4E organization was not formally in place at the time when the first ITER schedule was required, some initial changes were experienced due to the modification in the EU DA organization structure. In addition, in the early stages of any organization, a methodology or quality assurance program is prone to initial problems that trigger changes and evolutions. Not only the source of information varies, but also how this information is introduced into the common schedule database.

Due to the magnitude of the project and to the very large number of its components and their manufacturing duration, the construction phase of the project is estimated to last approximately ten years. Therefore there is the need to properly plan the work to be able to manage short-term activities and to identify interfaces at any time along the project. The long duration, together with this level of detail, rapidly increased the complexity of the schedule.

These factors led to schedule information which was detailed enough for schedulers to apply project control, but made it difficult for Technical Responsible Officers to read, follow the logic and thus to maintain the required high quality input to planning officers.

In collaboration with IO, F4E significantly contributed to defining best practices and schedule convention for the purpose of bringing the DWS to the high quality required by this complex and integrated project schedule system.

The main elements contributing to keeping high quality and homogeneous DWS are:

a) “Self explanatory” activity name (not relying on the parent WBS) always indicating work type, subject of the work and quantity. This is an essential criterion since the single generic activity is used as-is in other contexts than the native DWS (e.g., preparation of work programme and financial decisions).
b) Each DA has different constraints in terms of developing their own single WBS. All DWS’ have to be coded according to the IO WBS declaring for each activity to which IO WBS it belongs. For homogeneity and integration purposes this and other codes must be used and maintained by all the DA’s. The other codes are needed for a variety of purposes (e.g., approval level of project change request, management of schedule interfaces, milestone categorization, procurement package correspondence, relevance for procurement agreements, project phase categorization, on-site location where activities are performed, product breakdown structure correspondence, risk float buffer activities, etc)
c) Schedule development is exclusively bottom-up, but with targeted final milestones which need to be matched as defined by the highest ITER control bodies such as the ITER Council.
d) Use of schedule schematics/templates for implementing in Primavera uniformly among the parties specific situations like, e.g., control points, interface milestones, float buffers.
e) Clear logic to maximize readability of the schedules, identification and removal of redundant activity relationships.
f) Schedule quality check-out lists used for internal F4E review and approval prior to schedule submission to IO.
g) Granularity of the DWS characterized by 2-month maximum duration for activities within a 2-year time wave-front, including at least one significant milestone per month and per system.
h) The DWS are resource loaded, but not resource driven (all DWS are based on the Primavera activity type “task dependent”). This allows early prediction of peaks of resource needs (typically implying on-spot outsourcing).
i) Monthly schedule submission to IO including data date (physical progress) and schedule refinement and consolidation (permanent on-going action).
j) Formal review and approval in the F4E document management system involving planning, technical, procurement and QA officers and senior management. The schedule interfaces in the submitted schedules are not activated (no finish-start relationship is put in place between a predecessor and its successor, belonging to two different DWS’, forming a schedule interface) as only the dates defined and validated in this way are a committal for the DA procuring in-kind. After analysis of the global integrated schedule, feedback is provided by IO to each DA in preparation of the following update cycle.
k) Detailed and formal management of deviations and project schedule change requests.

The F4E enterprise, environmental factors and the organizational process assets have been taken into account to grant full integration of the schedules.

Each F4E DWS is at a different stage of development depending on its specific time frame and on the maturity of its inputs.

The information derived from these schedules is then compiled and examined as a whole from different aspects. First and foremost, the overall budget is derived with its yearly amounts. Depending on the specific available appropriations per year, schedules are rearranged by reallocating contracts and introducing options to be activated in different years.

Furthermore, the number of contracts to be launched and then run in parallel is analyzed, allowing F4E management to estimate the number of resources needed to carry out the activities. This analysis can have an impact on the schedule, when a peak of resources needs to be leveled by spreading out these activities over a longer timeframe, thus increasing the duration of the overall project.

An overall risk analysis is performed to pre-mitigate likely causes of delay. This results in changes in the procurement strategy such as, e.g., the introduction of a prototype, the completion of the detailed design before material procurement or the decision of purchasing a more accurate amount of material as a budget containment measure.

F4E has a well defined set of procurement rules derived from those used by the European Commission. This peculiarity results in additional parameters, which have to be taken into account while developing and managing the schedules.

7. Integration within the overall ITER project schedule

F4E schedules are subject to several integration processes, the main one being carried out by IO. Its aim is to compile the ITER project schedule reference baseline in terms of SMP, integrating the full set of DWS, as the SMP is a milestone-based roll up of the DWS themselves. IO has the duty of keeping control of all the deliverables and of the inter-DA schedule interfaces.

In the definition process of the current baseline, a few EU systems were identified as on the critical or near critical (float ≤ 30 days) path. F4E has investigated various procurement strategies and alternative fabrication routes to reach the current balance between time span, available budget and resources while reducing the global risk.

The remaining systems have a float which will lead to the execution of the work with no need for major mitigation actions in case of delays.

The number of non critical systems and the amount of related float has determined an acceptable global confidence level.

IO collects all the DWS' from the DA's, detects schedule interface violations "as submitted" (the predecessor declared finish date after the successor declared start date), identifies and prioritizes the schedule delay drivers, triggers actions at planning / technical / management level to fix / manage these interface violations. This process generates new input to the DA's, which then reconcile their schedules accordingly.

Remedy actions which cannot be implemented at schedule level within one update cycle are kept as schedule variances. These variances are intended to be temporary, i.e. they are declared when the delay has a possibility of being absorbed in the short term. After a certain period, if remedy actions related to a schedule variance cannot re-establish the original baseline, a project change request procedure has to be initiated to amend the baseline. The project change request is coordinated to involve all affected parties.

8. Integration with F4E supplier schedules

The granularity of a supplier schedule related to the execution of a single contract is much higher than the DWS, and thus the supplier schedule is summarized at a level which allows F4E to manage all undergoing activities without losing the overall perspective. This methodology allows small delays to be absorbed and more significant delays to be completely transparent to IO.

In order to carry out quickly and effectively a comparison between supplier schedule and the corresponding part in relevant DWS, this latter is replicated one-to-one, but using levels-of-effort (hammocks) in the supplier schedule, where, during the phase for baselining the supplier schedule, the start and finish dates per each level-of-effort is identified in the core of the supplier schedule jointly by F4E and supplier technical managers in charge.

This system allows easy identification of deviations. This is a sort of second-level checking, since deviations from the baseline are detected in real time by the F4E staff following up the execution of the contract at the premises of the supplier.

9. Management of schedule interfaces

The integration of schedules calls for a way of identifying relationships between different Primavera project schedules (at DWS level) among the ones of F4E itself and among the ones of all the DAs and IO.

This situation is managed with the definition of pairs of Inter-Project Links (IPL's) forming the ICT. An IPL is a standard finish-start schedule relationship linking two activities belonging to two different Primavera project schedules as explained in Section 4. An IPL pair defines a one-to-one type schedule interface (see Figure 4), other types, like, e.g., many-to-one, can be converted in a set of one-to-one type IPL pairs.

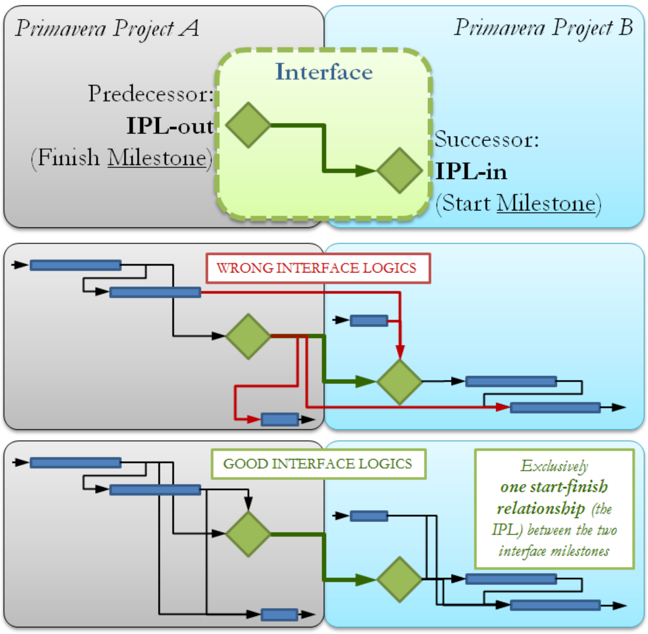

Figure 4: IPL pair implementation

The first step of the schedule integration is performed in-house by F4E on the European project schedules, which allows performing a consistency check before the EU schedule information is submitted to IO.

Although every component procured by F4E is formally delivered to IO, by a handout of responsibility, this will not necessarily be delivered to IO site, but rather to the destination where it is needed for the following fabrication / assembly step. When this next step is under European responsibility, an EU-EU schedule interface is identified and the related IPL spanning two different DWS' is activated (put in place) directly by F4E. The same concept is also applied to the interfaces between EU and the other ITER parties. Figure 5 shows the number of these interfaces where the major role played by EU is clearly visible. It presents all the DAs predecessors to EU activities who at the completion of the fabrication route deliver the final product to IO.

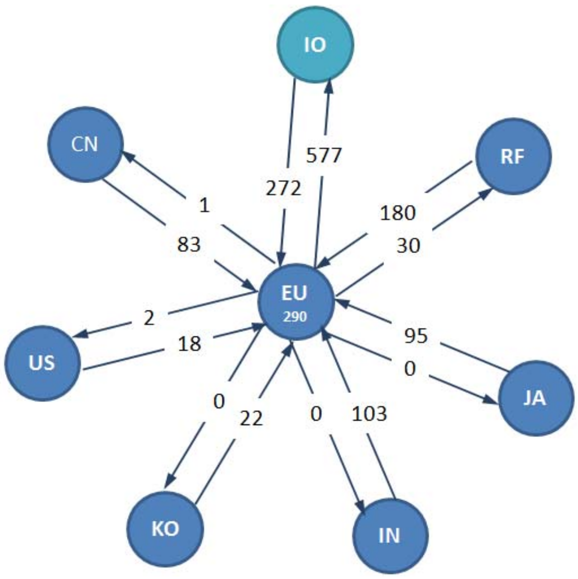

Figure 5: Schedule interfaces between EU and the ITER parties

10. F4E management and the Primavera schedules

The Primavera DWS-based procurement tool is also used for a number of scopes inside F4E:

- The Project Office uses it to produce executive documents. The Annual Work Program and the Project Plan are drafted and consolidated through the extraction and update of the information from the Primavera detailed WBS schedules database.
- The engineering department (the ITER Department of F4E) uses it to assure the systems technical needs and the number of contracts needed to fully cover the scope.
- Such Primavera tool is intended as reference for contract breakdown & budget data and grants an effective F4E inter-departmental communication channel.
- Primavera is one of the key tools of the F4E Integrated Project Management System.

11. Conclusions

F4E has implemented best practices in developing its own procurement schedules for the ITER project and Primavera P6 is the key tool for the optimization and management of the F4E schedules.

Schedule quality and very close coordination among involved parties (IO, other DAS and suppliers) is a mandatory requirement and Primavera P6 is globally an asset to manage highly integrated and complex projects for all the ITER parties

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