Project Configuration:
Making Project Management Software More Useful

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ABSTRACT

Many project teams are challenged in the early project phases by basic project management issues, such as the project organization, scheduling and contract form. This is often especially evident with EPC and other types of design-build contracts. Project partners are increasingly taking on roles in infrastructure projects that they have not traditionally had.

One issue to address early is the initial development of engineering and construction schedules. The work schedule determines the pace of the project. Unrealistic expectations in the initial schedule lead to disappointments, which can be difficult to rectify. Better use of traditional project processes and structures, often overlooked in today's spreadsheet and PowerPoint culture, provides a means of developing more realistic work schedules.

As used in this paper, project configuration will refer to the structures required to set up project management processes. This paper is an attempt to structure and to explain the project management processes used by Consultants in the construction industry, in terms that software engineers can use to implement these structures for project configuration and to provide the required data exchange interfaces between project management software tools. A workbook approach for the initial structuring of projects is suggested to configure project management software.

Engineers and project managers with prior experience in the type of work being undertaken must be involved early in the project. Many projects however have a difficult time with documenting and structuring advice provided by senior staff into the project configuration. A structured approach is essential to guide the early project work.

Project management structures important for the early project phase include a work breakdown structure (WBS), which includes all the project's physical features. The WBS should be of sufficient detail to support the division of work into contracts and to support the choice of the project delivery system.

Turning to the project work schedule as an illustrative example, a scheduling framework including the WBS, planned project phases with milestones, together with an understanding of the design and tendering workflows provide a solid basis from which to define all specific design tasks and construction activities.

Project phases for design, tendering and construction have to be determined based on external constraints (e.g. approvals and financing). Project workflows must be thought through for feasibility design, basic engineering, tender design and detailed design, together with all necessary review, interfacing and approval requirements.

1. INTRODUCTION

Starting a construction project off on the right track is important. It isn't easy. There is no time to learn as you go. You have to make use of the people, knowledge and tools at your immediate disposal. A lot of flexibility is needed in the approach to getting projects up and running, because every construction project is different, with different site layouts, different project organisations and different aims. But this should not happen without proper oversight and controls. While all companies have financial and legal controls, there is a lack of practical advice and software tools to pull projects onto the right start-up trajectory.

Compared to other industries, construction projects really are different. Many industries have large development projects followed by long production runs (e.g. the new Boeing 787). This is very different from construction, where each project requires its own development and design, with short time frames for planning and fewer resources available for project management. This makes the project management of construction projects challenging.

Many construction projects are not started off on the right track, frequently due to an undisciplined and unstructured approach to work scope, organisational structure, work schedule and cost breakdown. When construction projects are started poorly, for example with unrealistic work schedules and too little scoping, everyone involved with the project will suffer. The subsequent failure to meet expectations leads to a decline in motivation and in team spirit. Measures to put the project back on track may then be as unrealistic as the initial procedures. All this leads to confusion and to continued lack of progress with development of the project and in the worst case to massive cost overruns. It is essential to get it right from the start.

Therefore this paper is about configuring good project management structures, right from the start of the project. As used in this paper, project configuration will refer to the structures required to set up project management processes. The project configuration discussed here should be suitable for both proposal management and project management.

The working approach to project management activities is greatly influenced by the software tools available to the project manager. The software tools commonly used by the project manager and their teams during project start-up have been developed outside the construction industry. There is a lack of integrated software tools which support project management as practiced in the construction industry. Software is used in a piecemeal fashion, each software requires its own configuration and data exchange is difficult.

The concept of a basic project configuration is not prevalent in construction project management, largely due to the rigid and unique input requirements of each project management software. For example, the organizational breakdown cannot be input into most scheduling software, even though resource allocation for work scheduling requires one.

This lack of a consistent project configuration leads to a duplication of project management work as well as to inconsistencies across the project. For instance, scoping is often carried out as a standalone activity, without correspondence between work scope and work schedule activities. All experienced project managers have experienced work scope items missing from the contract work schedule, often causing unforeseen work effort and cost.

The project management structures and processes elaborated in this paper are part of the traditional practice of project management in the construction industry and are well known. They are briefly reviewed in order to understand their importance in the early project phase.

This paper focuses on project work scheduling, chosen because the scheduling process demonstrates both the usefulness of a base project configuration and its software implementation.

Project management software tools are needed which recognize and support the structure and processes used in the construction industry. A more consistent approach within the construction industry, to these structures and processes, is a prerequisite to the development of better project management software tools. Industry support is required to develop such tools. Our fate is in our own hands.

2. CONCEPT OF A PROJECT CONFIGURATION

As used in this paper, project configuration will refer to the structures required to set up project management processes. The aim of this paper is establishing a project configuration which can:

- input the required structures for project management processes and
- be effectively implemented in project management software.

These project management structures include project breakdown structures, such as a work breakdown structure (WBS), organizational chart, cost account and contract breakdown. They also include document classification and coding schemes.

It is important to keep the project management structures and processes to the minimum, yet still provide the necessary project oversight and control. These are the methods which all project managers within a company or client organisation should follow.

The project management structures are important inputs for the core project management processes of:

1. scope management
2. project delivery system
3. work schedule
4. organization
5. cost control.

In order to effectively carry out the project work and to achieve the project deliverables, the configuration of a number of project management support processes are also required. These include document management.

The project baseline should not be confused with the project configuration as defined in this paper. The project baseline, which is typically defined in an inception phase once the project has started, establishes:

1. site conditions (e.g. baseline geotechnical report)
2. design (employer's requirements)
3. work schedule
4. cost estimate
5. risk register

Establishing the project baseline proceeds systematically when the project management structures and processes are already configured.

Project management structures **Project configuration**	**--> Project management processes**	**--> Project baseline**

A well developed and documented project configuration is also the foundation for an effective quality management system.

3. PROJECT MANAGEMENT STRUCTURES

The basic structures required to set up project management processes, referred to above as the project configuration, typically include:

1. scope statement
2. work breakdown structure (WBS)
3. deliverables list
4. organisational chart (also referred to as the resource breakdown structure)
5. responsibilities-authorities matrix (staffing chart)
6. design checking and approval workflow
7. project phases
8. milestone dates
9. division into contracts (depending on project phase)
10. cost account structure
11. document classification and coding scheme

The scope statement summarizes the work to be done under the contract, including all work outlined in tender documents and all additional work identified during clarifications with the Client and included in the engineering services contract.

The work breakdown structure (WBS) captures all work tasks to be completed during the project and decomposes the project into smaller and more manageable parts. The WBS is important for the work schedule, for document management, for the division of the work into contracts and for preparation of a Bill of Quantities (or Schedule of Payments for EPC contracts). The WBS can in general be either functionally oriented (typical for feasibility studies before all project components are identified) or physically oriented (typical for construction phase using either the physical project layout or a schematic layout). It is often best to develop a separate WBS for each project phase, revising and adding detail. The WBS is composed of several tiers:

- Uppermost tier is the project itself.
- Second tier shows the major facilities to be constructed (e.g. stations and tunnels for a metro or dams, waterways and powerhouse for a hydropower project).
- Third tier typically shows sub-facilities (e.g. floor level for a metro station or powerhouse).
- Fourth tier typically breaks down work by discipline (e.g. geotechnical, structural, mechanical, electrical, architectural).
- Fifth tier may be used to identify components (e.g. base slab, walls, track platform, mechanical rooms for platform floor level of a metro station).
- Sixth tier (or lowest level) identifies work packages (e.g. for detailed design, construction design, construction execution for each of the individual components of a design-build metro station).

The contract documents (or tender documents for proposals) must be thoroughly reviewed to identify all deliverables. Deliverables in the design phase typically include design reports, design drawings and tender documents. The contents and level of detail of the design reports and design drawings depends on the design phase (e.g. feasibility, planning, tender) and on the project delivery system (e.g. design-bid-build, EPC). Typically the deliverables would be included in the sixth tier of the WBS.

The organisational chart determines how technical and project management decisions are made and also determines information flow within the project. The overall responsibilities of the project manager, lead engineer, discipline engineers and remaining project staff must be defined.

The responsibilities-authorities matrix relates the organizational chart to the project WBS. Technical and managerial responsibilities and authorities ("competences") are assigned for all key positions, with each element of the WBS assigned to the responsible person with the appropriate authority (e.g. designer, checker, approver, submitter).

The design checking and approvals workflow regulates how design packages and other project work are started, carried out, checked, approved and submitted. This includes internal workflows (design team) as well as external workflows (Client or Client's representative, vendors). The required time period for all reviews and approvals must be defined.

The project phases are defined according to the Client's overall project planning and with consideration of the project delivery system. Milestone dates are defined according to the Client's overall project planning with consideration of expected construction progress.

The division into contracts is a breakdown structure of all engineering and construction contracts envisioned by the Client (or Consultant as Client's representative) to complete the project work. This breakdown can only be established after completion of feasibility and planning studies (or basic engineering for EPC contracts) and is strongly influenced by the chosen project delivery system.

The cost account structure includes all work to be done for the project. There may be separate account structures for the project and for participating companies (who have their own accounting requirements) and the different account structures have to be keyed. The cost account structure serves as the basis for budgeting and monitoring project costs.

The document classification and coding scheme defines all engineering and administrative classification attributes for documents (e.g. WBS, location, work type, project phase) and a coding scheme for documents (may have differing coding schemes for different document types). All document types must be defined.

Definition of the project configuration, as discussed here, can be assisted by suitable computer software. One can envision a setup routine that uses a workbook methodology to define the structures of the project configuration. The software should lead the project manager through all project management structures, using input forms and terminology understandable to him. Feedback should be provided using charts and diagrams common to the industry (e.g. an organisational chart which can be presented to the Client, a division into contract which can be included in contract documents). It must be also be easy to correct mistakes and inconsistencies. The aim is to make the project configuration available as input to all project management software.

4. WORK SCHEDULING USING A PROJECT CONFIGURATION

Having established a base project configuration, the development of a project work schedule should proceed logically and efficiently using scheduling software. The following summary methodology is not specific to particular software tools, but does presume the project configuration structures data can be conveniently input electronically into the scheduling software. The software requirements (and current shortcomings) will be addressed in Section 5 of this paper.

1. As a first step towards a project work schedule, the completed work breakdown structure (WBS) is input into the scheduling software. This ensures that the overall scope of the work is correctly input. It also provides a logical structure for development of the work schedule.
    - The deliverables list is input at the lowest tier of the WBS as work packages.

2. Project phases are input together with the project milestones to establish the overall scheduling framework.

3. The organisational chart is input as a resource breakdown structure. Relationships between the WBS and the resource breakdown structure already established (in responsibilities-authorities matrix) are preserved in the work schedule, eliminating duplicate effort and inconsistencies in the project setup.
   If a division of the project work into contracts has been established, the contracts should be included as part of the resource breakdown (or alternatively input using a contract breakdown schedule with a defined relationship to the WBS).

With the above inputs, a scheduling framework is defined together with overall resource assignments.

4. All activities can now be added which are required to further define the work, to estimate the manning and cost (proposal stage), to execute the work and to control the work. The activities are input following the WBS, providing a clear scheduling structure and allowing consolidation of the scheduling results at each level of the WBS.

Resource assignments are generally automatically assigned following the relationship between the WBS and the resource breakdown structure. Specific assignments can be adjusted.

Another challenge is the schedule's level of detail. This must be sufficient to ensure all engineering and construction activities are included, but not so detailed that oversight is lost.

5. The effort (e.g. work hours) required for each activity must be estimated. External data sources with design production metrics (e.g. based on historical records from similar activities or on number of drawings and complexity) and with construction production rates or metrics may be used for estimates. Ideally the external data sources can be accessed from within the scheduling software.

The required effort for individual design activities (e.g. design packages) must take into account the required checking, approval and revision workflow, which has been prepared as part of the basic project configuration. It is usually not necessary to include this level of detail in the work schedule itself, as it is more convenient to separately develop and monitor deliverables lists

(e.g. drawing lists) that show the complete scheduling details for each document (or package). Doing this efficiently requires however that the work scheduling software and the document management software can exchange the relevant scheduling data (e.g. for design packages), for which it is advantageous to use the document codes assigned to deliverables and to design packages to ensure correct data exchange.

6. Resource constraints for the project team are input, as defined by the resource breakdown structure as e.g. available working hours per week for project work.

The durations of each activity are computed.

7. Scheduling logic (constraints) is added to the activities, defining the work sequences, and establishing the critical path and floats.

A network diagram is the preferred way of establishing scheduling logic. For linear construction such as railroads and tunnel, an additional presentation of construction activities using time-distance diagrams is useful for cross-checking. The product of this step is the work schedule, which can be optimised, monitored and revised during the project.

8. The activities and the budgeted effort for each activity, with resource assignments, are available for input into the cost control software used by the project.

Considerations should be given to structuring the cost accounts (or at least one component of the account code) using the WBS, allowing consolidation of costs for reporting.

5. SOFTWARE IMPLEMENTATION OF A PROJECT CONFIGURATION

Software is increasingly becoming a bottleneck in managing project configurations. Systems exist to support all the individual processes (or at least parts of them), by they are unable to share data in any meaningful way. The result is that the same data, typically in different forms, must be entered into multiple systems. The result is an overall loss of rigor:

- Updates and corrections must be made in multiple systems
- Data in different systems is extremely difficult to cross-check for consistency
- It is often unclear which system is authoritative in case of discrepancies
- There is a tendency to cut corners and ignore data, due to the sharing difficulties
- Due to the data islands, collaboration between project team members is reduced

The use of a project configuration as outlined in this paper allows for more effective project management.

As an example of typical current scheduling practice, during tendering for engineering services and during feasibility studies, work schedules are often prepared using Microsoft Project. However, in our experience, Microsoft Project based project schedules typically are not based on a work breakdown structure (WBS), do not use scheduling logic and do not formally consider resource constraints. Such schedules are therefore just as often prepared using spreadsheets.

For more comprehensive engineering services, such as during the planning and tendering phase, the use of a work breakdown structure (WBS), scheduling logic and resource constraints is required. While it is possible (and quite common) to develop structures and constraints on paper or in spreadsheets and then “publish” them in Microsoft Project, this is tedious and error

prone. The revision process is especially inefficient, partly due Microsoft Project's inability to import the WBS and other breakdown structures. The required workarounds force a loss of overview and increase the risk of transcription and other errors.

During construction tendering, and especially during construction, the Primavera suite of scheduling programs is commonly used. Primavera provides sophisticated scheduling logic including the development of a WBS, full support for resource constraint management, and sophisticated reporting. The disadvantages of Primavera are mainly related to its cost, including both the cost of the software and the training required to use it effectively (most Primavera users are specialists, with years of Primavera experience). A further serious issue is its lack of support for real collaboration within the project team (intra-company collaboration is supported, but it is not suitable for projects involving many companies) and to its proprietary data format, which makes it difficult to exchange scheduling data with other software.

The main problem with the approaches outlined above is the lack of support for effective collaboration, which limits participation in the scheduling process to a select few. This is because the currently available software makes it is nearly impossible to include the entire project team's knowledge, which results, to those not actively taking part, in a "black box" result. Given that the majority of project team members haven't contributed or been involved in the process, they are unlikely to really commit to the resulting work schedule.

Successful implementation of project management software requires setting up a project configuration which includes all project structures and which is used commonly by all project management software. Robust data exchange procedures are indispensable. In our opinion, there is a real need in the heavy construction industry for improved software tools for project configuration and work scheduling, tools that do not require excessive training (e.g. based on well-known construction procedures) and tools that support collaboration across the project team by being able to share data.

Other industries have already reached a high-level of data integration, including truly integrated software support systems. The secret is to concentrate on the meaning and importance of the data and to ensure that all software systems are able to export and import data in formats that engineers (as opposed to software specialists) can understand. In practical terms this means avoiding proprietary formats, and instead using text-based self-describing data formats, such as CSV, XML, JSON, or SQL. Text-based data formats allow engineers to use simple tools to perform basic filtering and manipulation of the data, allowing it to be fed into other systems. A further benefit is that the data is also available for other uses.

With this approach, by importing and exporting data, the relationships between the WBS, the resource breakdown schedule and the cost account also make scheduling and cost data available for the reporting required for effective project monitoring and control.

6. CONCLUSIONS

1. It is important that the project structures are well defined from the start of the project. This is often not the case and requests for proposals, proposals for engineering services and contracts often do not provide well defined structures such as for the work scope, organisational structure and work schedule.

2. Project management processes require the consistent definition of project structures, including breakdown structures for project work, for the organisation, for contracts and for cost accounting, as well as document classification and coding schemes.
3. The base configuration of the project structures can be set up with software routines using a workbook approach and made available for input to project management software tools.
4. Project management software tools must be reworked to allow exchange of project management data across the different software tools.
5. The construction industry should agree and mandate data standards for construction project management.
6. Software technology is readily available to implement the proposed project configuration approach.

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