Abstract

I made this final thesis in the planning section of Saipem, an engineering company specialized in the Oil& Gas industry. In this competitive business, planning team is a key element of the project. Indeed, price, technical solution and lead time are the decisive factors to win a project. In execution phase, planning team must highlight to key project’s managers critical points and control progress, so that the effective duration of the project is consistent with the contractual duration.

The main objective of this thesis is to realize a typical schedule of engineering for an onshore plant. This typical schedule must be a referent tool for planning engineers working on a real project. This document must contain: an exhaustive list of engineering activities, a typical codification for engineering activities, and, the most important, typical logic sequences of engineering.

To fulfill this objective, I first had to study engineering, then I had to learn how to use “Primavera P6” - project management software - and I finally had to merge those skills to realize the “Engineering Typical Schedule”. To study engineering, I had to understand the breakdown structure of this phase of the project, to understand technical content of main engineering activities, to identify inputs and outputs of these activities and their relationships. After implementation of the schedule into “Primavera P6”, I had to analyse the schedule I did to correct it, to make it consistent, and to strengthen the credibility of this document.

The result of my internship is a typical schedule designed to make easy its use by planning engineers on a real project. I made a typical structure compliant with engineering organization in Saipem and I grouped sequences of activities into typical sequences to put a special emphasis on main logics of engineering. Besides, I worked on a “Handbook for planning engineers” and add many comments on the schedule so that it can be considered as a training tool for junior planning engineers as well.

To conclude, I am very satisfied with this professional experience. I think I have reached the target and made an efficient tool for Saipem. Besides, I gained specific project control knowledge thanks to my final thesis supervisor, Mr Olivier Nègre, head of planning section for Saipem.
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1. Preface

1.1. Origin of the project

This project is included into continual improvement process of planning section in Saipem.

The main goal of this project is to unify methods of scheduling, to define a typical structure adapted to Saipem organization and to create a referent tool which summarizes standard engineering activities, standard durations and standard logic sequences.

This way, typical schedule will enable time saving and will make easier the job of planning engineers to create a new planning. Instead of taking data from planning of similar projects, the typical schedule will be a referent tool approved by all discipline leaders and will comply with standard scheduling rules.

1.2. Motivation

I am very interested in working into Saipem project control department because it is one of the major engineering companies in the world, specialized in complex mega projects realization. Thus, I was convinced that working in this company could be an excellent way to learn best project management methods.

I have a special interest for planning section because I am sure planning is a very good way to have an overview of the project. Besides, making a typical schedule for engineering, which is the most complex phase of the project, is an interesting challenge for an industrial engineer. To take up this challenge, understanding of all main engineering activities and all main relationships are required. I think this step is necessary for an engineer who wants to work in project control, and I am proud to be able to do it in one of the most famous engineering company.

Moreover, I know this internship is a good opportunity to develop and enrich my skills in project management. It is one of the best way to get ready to start my career in “Project Control”, what I have been longing for a long time.

1.3. Organization

To make this job, I was a member of a team whose composition was changing during the project, as we can see:

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2. **Introduction**

2.1. **Presentation of SAIPEM SA**

SAIPEM is a complete Oil and Gas service provider. It is owned at 43% by ENI (Ente Nazionale Idrocarburi), a major petroleum company. SAIPEM was created in 1957 and has now a presence in more than 70 countries with 37,000 collaborators. SAIPEM structure falls into three business units:

- **Onshore**
- **Offshore**
- **Drilling**

In 2010, revenues of SAIPEM were more than 10 billion euro, with 47% for Onshore, 43% for Offshore and about 10% for drilling activities. The last few years, SAIPEM won several multi billion dollars projects in countries like Nigeria, Angola and Algeria. Main Onshore activities are:

**Natural Gas Liquefaction and Regasification**

Saipem has gained a strong presence in the natural gas liquefaction market, with a remarkable track record of 9 base-load trains built over the last decade in Nigeria and in Qatar, for a total production capacity of over 35 million ton per annum.

Currently, Saipem is executing its first EPC contract as main contractor for Sonatrach's Arzew LNG Project in Algeria. This 4.7 MTA project will be the largest LNG production facility in Algeria and one of the largest ones in the world. Recently, Saipem has also performed front end designs for new large LNG projects in Nigeria and in Egypt.

**Oil Refining**

Saipem has designed and built 37 grass-roots refineries in Europe, Africa and the Middle East, as well as more than 500 individual process units in almost every corner of the world.

In response to the market shift during the last years, Saipem onshore has more recently focused on designing and building “bottoms-of-the-barrel” and heavy oil upgrading complexes added to traditional
or new oil refineries, by implementing large investments based on hydrocracking, hydroconversion, solvent deasphalting and residue gasification process technologies, in Italy, for Eni, ERG and others; in Canada, to process oil sands for Canadian National Resources Ltd.; significant refinery expansions in Morocco, for SAMIR, and earlier in Poland and Mexico. A recent Front End Design was executed for a new project in the Russian republic of Tatarstan.

**Petrochemicals and Gas Monetization**

Employing a combination of proprietary and top-of-the-line third party technologies, Saipem has designed and built more than 400 plants worldwide to produce chemicals, mostly from natural gas. These include integrated complexes to produce Urea, a leading fertilizer, based on Snamprogetti™ proprietary technology, licensed to date to 115 units. In particular, the world’s largest single train urea complex at Profertil in Argentina, and the world’s largest urea single project, for Omifco in Oman.

Saipem is currently building what will be the largest single train complexes in the world, for Engro, Pakistan and two for Qafco, Qatar.

This in addition to numerous other petrochemical projects based on technologies from traditional partners, such as Dow, Univation, Polimeri Europa and other reputable licensors, in diverse markets ranging from China and Qatar to Italy, Brazil.

Saipem is currently executing the Gas-to-Liquids complex for Chevron Nigeria Ltd., together with a partner. Utilising breakthrough technologies from Sasol, Chevron and Haldor Topsoe, this plant will produce premium diesel and gasoline from natural gas. To minimize construction at a remote and swampy site in Nigeria, where there is lack of space and a shortage of skilled construction resources, large modules have been fabricated in a specialized yard, in Abu Dhabi, U.A.E., under Saipem’s onshore design, supervision and overall contractual responsibility, then shipped to the site at Escravos, Nigeria.

### 2.2. Organization of an “Engineering Procurement Construction” Project

Major projects contracted by Saipem are “Turn Key” projects, or “Engineering Procurement Construction” projects.

**Engineering:** design and conception of the plant.

**Procurement:** purchasing equipment and material required for the construction of the plant.
Construction: building the plant and management of construction.

A few data for onshore EPC projects:

- Budget: from 100 million euro to more than 2 billion euro
- Engineering man hours: about 500 000 hours
- Construction man hours: about 3 000 000 hours

Projects realized by Saipem are international. Engineering is first realized in Paris and then subcontracted to low cost centers in India, suppliers are all around the world and construction takes place in Africa (most of the time).

As a conclusion, these projects are complex to manage, and complex to realize because of technological challenges.

2.3. Organization of the “Project Control” Department

The “Project Control” department is divided into three sections:

- **Cost Control**: for each project a cost structure is created (“Cost Breakdown Structure”). A budget is dedicated to each part of this cost structure and the main goal of the cost control team is to make sure real expenses for each part of this structure are consistent with previous budgets. Cost control team also has to make the bill for client, following progress measurement made by the planning team.

- **Risk Management**: we are talking about financial risks. A risk manager has to lead brainstorming, before contract award, to identify risk and opportunities and to assess potential “cost overrun”. During project execution, there are “risk owners” in charge of risks management.
- **Planning**: responsible for time control. It is a key section for the project, both in bidding and execution phase. In bidding phase, it can be a key element to win the project and in execution phase, it is one of the main interfaces with the client. Indeed, the project’s schedule is regularly updated and the “Finish date” is re-evaluated. The main objective of the planning team is to prevent delay and avoid high penalties. Besides, as we saw before, progress measurement of the project is a key data to prepare client’s bill and evaluate the productivity.

All concepts of “Project Control” are linked, “Cost Control”, “Planning” and “Risk Management” are inter dependent:

![Diagram showing interdependence of Cost, Risk, and Planning]

2.4. **Target of the project**

For my internship, I have to make a typical schedule of engineering for an onshore project. This schedule must be a starting point for planning engineers. It must satisfy the following objectives:

- Define a typical structure
- List all standard engineering activities, with associated durations
- Define logic sequences between activities

2.5. **Scope of the project**

I have to schedule engineering phase of an “EPC” project. To realize a complete standard schedule, it would be necessary to continue my job with the typical schedule of procurement and construction phases.

The typical schedule is not a document imposed to planning engineers. It is a tool to help them working faster and better. The standard schedule has to be adapted to the specificities of each onshore project.
3. Description of existing work

3.1. EMC : Engineering Management Class

This document is a standard corporate document. The purpose of the EMC is to list, to define, to standardize and to describe all engineering activities relevant to onshore plants. The standard schedule must be based on the EMC.

The EMC covers the whole cycle of a project, excluding construction, from basic to detailed engineering to delivery of materials at site. It is a reference tool for engineering processes and a starting point to set the planning and the control of projects for onshore plants.

Onshore EMC had been first issued in 1986 and since this date, it had been regularly updated in order to consolidate the experience acquired with projects execution and to create an exhaustive database for engineering activities.

Engineering is structured by disciplines. The breakdown structure is:

All activity durations are based on the hypothesis of a standard Project EPC, whose schedule is:
Status for main deliverables are based on the following rules and process:

Approach to Technical Documents handling and issue

In order to optimize the project progress, the following is the approach to be followed:

1) Acknowledgement of bid documentation, renumbering of the project, confirm of the existing mechanization, updating by implementing of technical modification as agreed during the bid phase as well as including new information by Client, issue for comments (IFC).

2) Completion of document mechanization, including comments and issue for Design (IFD)

3) Acknowledgement of comments, updating with new information (by Vendors) and issue for Construction (FC)

4) As built as for actual modification during the construction phase

Flow chart of Document Approach is indicated below:

Typical process for deliverable status

In each discipline, activities are grouped and sorted by “EMC Index Form”. There is a total of more than three hundreds EMC Index Forms for all engineering activities. Here is an example of an EMC Index Form, with the detail of main information we can find on it:

On Shore Management Classes Data Book

Rev. 1 (2008)

Summary description

Includes all the activities relevant to the preparation of: (a) process data sheets for equipment; (b) functional specifications needed to define Package systems. Also includes all the support activities in the Technical Departments concerning: (a) definition of supply limits; (b) support to preparation of the technical evaluation (in accordance with remit); (c) supply follow-up; (d) definition of auxiliary systems

Physical components

Note: [commodity group] ( )

Description of activities, incidence and duration

Process Specifications for critical Equipment/Package
Process Data Sheet for Equipment
Follow-up
EMC Index Forms are issued by SAIPEM Milano, the head office. Consequently, there are based on SAIPEM Milano organization, which is a bit different from the SAIPEM SA organization, based in Paris. To realize the typical schedule, it is required to adapt this structure.
3.2. “Handbook for planning engineers, v0”

This handbook was written by a trainee and is aimed at junior planning engineers. It is the result of interviews with all discipline leaders (Process, Piping, Electrical…), and it deals with main engineering activities realized by each discipline. This is a description of all typical engineering activities performed and all typical documents issued during the engineering of an onshore plant.

Example of the content of this handbook, for “Piping” dedicated part:

Index for “Piping” dedicated part

A) Plot plan
B) Setup 3D model - (Installation du modèle 3D)
C) Preliminary routing - and - Preliminary stress
D) PID, UFD and calculation
E) MTO 1 (Materials Take Off)
F) 5D model - (modele 5 Dimension)
G) MTO 2
H) Economic analysis
I) MTO 3
A) « Set up 3D model »

- There is only one 3D Model, which is segmented. Each discipline can work on his own segment.
- 3D Model is designed with PDS (Integraph) or PDMS (Aveva). There are softwares.
- PIP is responsible of 3D Model supervision

3D Model Set up includes setting of interface with the dedicated software for material supply (MARIAN). Piping Material Classes are created with MARIAN and interfaced with the 3D software. This interface is aimed at managing bill of quantities for material supply.

B) « Preliminary routing* » and « Preliminary stress »

When designing « preliminary routing* », « equipment layout »* is not frozen.
- « Preliminary routing* » is the 2D layout drawing of main piping routing.
- « Routings » for underground piping are first realized.
- « preliminary stress » are stress calculations aimed at freezing routings for critical lines.

Extract of content for “Piping” dedicated part

The last part of this handbook is dedicated to the most important flows between engineering disciplines.

There is no link between this document and “Engineering Management Class” (EMC). It is a description of how engineering works in SAIPEM SA, of the main documents issued and of the main relationships between disciplines. For example, the structure of the handbook is different from the structure of EMC, and activity names in the handbook do not always match with those in the EMC Index Forms.

To sum up:
4. **Project Requirements**

4.1. **Tool: Primavera P6**

Primavera P6 is the software used by SAIPEM SA to schedule its projects. This software is one of the highest standards used in scheduling major projects (software used by Areva, Total, Technip, Hyundai, Samsung, SNCF…). It is a powerful and complex tool used to schedule activities (several thousand activities for projects realized by SAIPEM), resources, and to control project’s progress.

Primavera P6 operates like a data base, several people can work on the same project at the same time. The main operating rules of P6 are:

- First: create an activity, identified by an “Activity ID” and an “Activity Name”
- Second: assign data to this activity (calendar, duration, relationships, resources, activity codes…)
- Third: define a layout, using filters and organization breakdown. This third point is very important. Thanks to this function, we can optimize organization of the schedule depending on the specifics needs, we can show only what we need.

The most important property of Primavera P6 is it “Multi Project” organization. All projects can be sorted in the same data base, what enable to share scheduling methods and to manage easily and efficiently the return of experience.
4.2 Schedule structure

First of all, it is important to remind that a planning is a communication tool. This document is a management tool and it is used by all the key people of the project. In spite of the quantity of information we can find through it, a planning must highlight the critical tasks and make easier the control of the project.

The structure of the planning is defined in Primavera P6 with “Activity Codes” and the WBS. These activity codes are similar to tags put on the different activities. An activity code can refer to a kind of activity, to a physical unit of the plant, to a work package, to a phase of the project, to an EMC... We can then create filters and organization thanks to the activity codes and then define layout thanks to filters.

The “Multi Project” conception of Primavera P6 makes possible the use of this standard structure for all projects.

Activity Codes defined for the standard schedule are:

- Department: to group and sort activities by engineering departments, following structure of engineering in SAIPEM SA

<table>
<thead>
<tr>
<th>Activity Code: DEPARTMENTS_FOR_EMC</th>
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<tbody>
<tr>
<td>PCS</td>
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<td>LPE</td>
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<td>PIP</td>
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<td>MAE</td>
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<td>CV</td>
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<td>MAN</td>
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</tbody>
</table>

- Unit: for projects with several physical units, to can create a layout for each unit of the plant

<table>
<thead>
<tr>
<th>Activity Code: UNITY</th>
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<td>U01</td>
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<td>U02</td>
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<td>U03</td>
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</table>

- Status: to filter on the status of deliverables. Can be especially interesting to see all scheduled dates of deliverable “Issue For Construction”, and the effect of a delay for the construction
4.3 Codification for activities

As the structure of a planning is important to emphasize the relevant information, the codification for activities is very important to quickly identify the activity we are talking about. For example, projects are often divided into several units, and the same activity can be repeated on each unit. In such case, the “Activity Name” is not sufficient to differentiate the activities. The activity ID must be unique in the project.

The rules we have to follow for coding activities are:

- **Unit**: for several units projects
- **Phase**: Engineering (E), Procurement (P) or Hammock (H)
- **EMC**: to link with EMC Index Form
- **Status**: to quickly identify the status of a deliverable (W = Issue for Approval, X = Issue for Design, Y = Issue for Construction, Z = As Built)
- **Activity Sequential Number**: to differentiate activities in a same group
Here is an example of an “Activity ID”:

<table>
<thead>
<tr>
<th>Unit</th>
<th>Phase</th>
<th>EMC</th>
<th>Status</th>
<th>Activity Sequential Number</th>
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</thead>
<tbody>
<tr>
<td>U00</td>
<td>E</td>
<td>PR01</td>
<td>X</td>
<td>6002</td>
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</table>

Moreover, we can filter on “Activity ID”, hence the significance of this codification.

Note: the values of the activity codes must be coherent with the activity ID. For instance, in the above example of ID, the activity code “Phase” must be “E” (Engineering).
5. **Knowledge prerequisites**

5.1. **Theoretical concepts for planning**

5.1.1. **Float and critical path**

The two previous points are very important concepts when scheduling activities. The main goal at the time of scheduling projects is reduce and minimize the time necessary to achieve the project. Then, in the execution phase, the main objective of project control team is to ensure that project will respect scheduled “lead time” and approved budget.

**Float**: it is the maximal quantity of time an activity can be delayed without postponing the end of the project. A float can be applied to a single activity or to the entire project.

**Total Float**: it is the maximal quantity of time an activity can be delayed without changing the “Late Finish” of the project.

\[
\text{Total Float} = \text{“Late Finish”} - \text{“Early Finish”}
\]

**Free Float**: it is the maximal quantity of time an activity can be delayed without postponing any other activity. There is always Free Float ≤ Total Float.

**Critical path**: it is the sequence of activities with null floats, from the beginning of the project to the end of the project. Any delay on the critical path will postpone the end of the project.

**Critical activity**: it is an activity located on the critical path, that is to say an activity with a null float.

5.1.2. **Different kinds of links**

A planning is a logic network where all activities are linked. There are four kinds of links: “finish to finish”, “finish to start”, “start to finish”, “start to start”.

**Finish to finish**: means that successor can end only if predecessor is finished.

For example, if “Activity A” is “Frame erection” and “Activity B” is “Frame painting”, we understand that we cannot finish “Frame painting” if “Frame erection” is still being erected.

**Finish to start**: it is the most frequently used link. Means that successor cannot start before predecessor is achieved.
Start to finish: means that successor can finish only if the predecessor has started. This link is rarely used.

Most of the time, it is a “trick” used without any real meaning.

Start to start: means that successor can start only if predecessor has started.

For example, the link between “Piping prefabrication” and “Piping erection” is a “start to start”. Indeed, “Piping erection” can start as soon as the first piping line is prefabricated. As we can depreciate the time needed to realize “prefabrication” of a single line, the link is “Start to start”.

5.1.3. Lag

A “lag” is a quantity of time which fills out a link. It makes possible a gap between two activities realized at the same time. It can be positive or negative.

Example of a positive lag:
Example of a negative lag:

![Activity A](#) → Activity B

5.1.4. An example: typical sequence

Here is an example of a typical sequence from the department “Equipment”.

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</tbody>
</table>

Technical Specification: it is a document which defines main criteria of study, of building equipment and technical requirements from engineering departments.

Material Requisition: it is a document made to produce a “Purchase Request”. The content of this document is: scope, applicable documents (technical documents for furnisher to make the equipment) and list of documents the vendor has to supply.

Technical evaluation: technical evaluation of different bids from vendors.

Vendor doc: documents that vendor has to supply to the company, to ensure equipment complies with requirements.

All the links between the different activities are links “Finish to Start”, expected between “Material Requisition” and “Technical Evaluation”. Indeed, the lag is the time necessary for the vendors to study the “Purchase Request” and to prepare their bid.

5.2. Specific culture in Oil and Gas industry

5.2.1. Main engineering activities

Of course, to schedule engineering phase for an onshore project, it is necessary to have specific culture in oil and gas industry. This is why the first part of my internship was dedicated to studying main engineering activities. It is required to understand main engineering activities, main links between these activities and main relationships between the different engineering phases.
5.2.2. An example: Piping

“Piping” department is responsible for the arrangement of plant, location of units, equipment... Besides, this department is responsible for the design of piping (above ground and underground) and main structures to support pipes and cables.

5.2.2.1. “Plot Plan” and “Single Line Diagram”

As we said before, geographical organization of the plant is under “Piping” responsibility. This goal is reached with emission of layouts called “Plot Plan”. An “Overall Plot Plan” is a general map of the plant, whereas a “Unit Plot Plan” is a map of a single unit.

First, there is the “Preliminary Routing”. This is a 2D layout of main piping routings.

![Example of an “Overall Plot Plan”](image1)

![Example of a “Unit Plot Plan”](image2)
“Piping” department is also responsible for the design of “Pipe Rack Single Line Diagram”. “Pipe Rack” is a structure (steel or concrete) designed to support piping and cables. “Piping” engineers design shape of the racks and they estimate the loads of the racks.

![Example of a “Rack single line diagram”](image)

5.2.2.2. “Preliminary Routing” and “3D Model”

One of the most important activities for engineering is setting and design of the “3D Model”. This is a computerized model of the plant, which shows all units, piping and equipment arrangement.

The functions of the “3D Model” are: make easier clash management (between piping, piperacks…) and coordination between engineering departments, and for the client, it can be a training tool for operators and a tool for maintenance.

![Example of a “3D Model”](image)

5.2.2.3. Underground Networks

Underground and above ground networks are differentiated, but both under “Piping” responsibility. The gravitational networks (for sewer water), pressured water for fire protection and electrical networks are underground networks.
5.2.2.4. “Isometrics” and “Material Take Off”

An “Isometric” is a 3D drawing of a piping line. This document is quoted but is not a scale drawing. It is extracted from the “3D Model” and it is the document used on a yard to start “Piping prefabrication”.

![Example of “Isometric”]

For EPC (Engineering Procurement Construction) Projects, the company has to buy material necessary for construction, and in this case, company has to buy piping. As “Piping” just need bulk material, MTO (Material Take Off) for piping are necessary.

MTO are bill of quantities required by the project, and basically, purchasing process is made of three stages, for a total of 15 months.

The first MTO issue is based on “PID (Issue for Approval)” and “Preliminary Routing”, the second MTO is an update of the first one while MTO3 is based on isometrics.

Each MTO issue is aimed to precise the whole quantity of piping material required.

5.2.2.5. Stress Analysis

The “Stress Analysis” is a study of loads applied on piping components. Loads applied can result from dilatation, disruption while processing... “Stress Analysis” reports mainly impact on piping routings and single line diagrams (estimation of loads imposed on rack).

For example, stress calculation can impose expansion loops on a piping line. An expansion loop avoids irreversible deformation and risk of fracture of piping, due to dilatation or shrinkage (fluid temperature variation).

![Example of an “Expansion Loop” along a piping line]
5.3. Conclusion

We have just seen main engineering activities for “Piping” department. The prerequisites skills for making a level 3 engineering schedule are project management theoretical concepts and a strong technical culture for oil and gas industry.
6. Methodology for planning realization

6.1. Global methodology

We had to schedule eight engineering departments, which means several hundreds of activities.

At the time of scheduling engineering phase, we had to take into account relationships “intra department” and relationships “inter department”. The method we chose for this exercise had to make possible:

- All trainees from the team can work simultaneously with independence
- Make easier progress control
- Enable approval process

We decided to schedule engineering departments one by one, to first link only “intra department relationships” and finally, to link “inter department relationships”.

To begin, we realized “Gantt Diagrams”, on paper supports and then, we implemented it into the software “Primavera P6”. We did “Gantt Diagrams” together and after, we split the schedule into trainee’s team by engineering department.

6.2. Adapting EMC Structure to SAIPEM SA Structure

6.2.1. Engineering department

We remind that “Engineering Management Class” was first issued by SAIPEM Milano, the head office of SAIPEM with a different structure from SAIPEM SA (in Paris). The typical schedule is aimed to SAIPEM SA and will be used by planning engineers from SAIPEM SA, so we had to adapt it to engineering organization in Paris.
The differences between the two organizations are:

- There is no “Pipelines” department in Paris, because it is a specific kind of onshore projects.
- In SAIPEM Milano structure, “Process” department is split into primary and secondary process technologies. There is no distinction between primary and secondary technologies in Paris.
- There is a “Material Management” department in Paris, whereas there are no similar departments in Milano.
- "Loss Prevention Engineering" is a part of “Process” department in Milano, whereas it is an independent department in Paris.
- “Material” is an independent department in Paris, whereas it is split on other departments in Milano (on Electrical, Piping, Loss Prevention Engineering and Equipment).

These differences of structure between our reference document and the schedule we had to realize were previously solved defining the “Activity Code” “DEPARTMENTS_FOR_EMC”. The best example is for “Material” department:

<table>
<thead>
<tr>
<th>Code Value</th>
<th>Activity Code Value Count</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE.EL</td>
<td>3</td>
<td>Electrical</td>
</tr>
<tr>
<td>MAE.EL.038</td>
<td>1</td>
<td>Cathodic Protection System - Design</td>
</tr>
<tr>
<td>MAE.EL.03C</td>
<td>1</td>
<td>Cathodic Protection system - Package</td>
</tr>
<tr>
<td>MAE.EL.01A</td>
<td>1</td>
<td>Piping</td>
</tr>
<tr>
<td>MAE.EL.01B</td>
<td>1</td>
<td>Materials Supply by contractors</td>
</tr>
<tr>
<td>MAE.LR</td>
<td>1</td>
<td>Process</td>
</tr>
<tr>
<td>MAE.LR.01A</td>
<td>1</td>
<td>Material Selection Report</td>
</tr>
<tr>
<td>MAE.LR.03</td>
<td>1</td>
<td>Loss Prevention</td>
</tr>
<tr>
<td>MAE.LP.03</td>
<td>1</td>
<td>Materials Selection</td>
</tr>
<tr>
<td>MAE.CL</td>
<td>1</td>
<td>Pressure Equipment</td>
</tr>
<tr>
<td>MAE.CL.06</td>
<td>1</td>
<td>Assistance to material selection and corrosion problems</td>
</tr>
</tbody>
</table>

Example of “Activity Code” hierarchy for Material department

We can see with this solution the synthesis between Paris and Milano structure. The schedule is structured following SAIPEM SA organization but we can read in the “Activity Code” the relevant department for the activity in Milano and the relevant EMC Data Sheet for the activity.

6.2.2. Group of activities

To try to lighten the schedule, I decided to group activities and create typical sequences. I did it for the department “Equipment” and for the purchasing activities in the department “Electrical”.

The department “Equipment” is divided into five kinds of equipment:

- Furnaces
- Machinery and engines for chemical and petrochemical plant
- Heat exchangers and Air Coolers
- Pressure Equipment, Columns, Reactors
- Energy Packages
- Process package and handling
Each “section” dedicated to a kind of equipment is divided into various index forms, one index form for one specific equipment. For example, there are about ten data sheets for “Furnaces”, more than ten for “Pressure Equipment, Columns, Reactors”…As activities, duration and predecessors/successors are similar into a “section”, I decided to create a typical sequence of activity for each section.

I did the same for the department “Electrical”. All activities concerning purchasing in this department can be grouped in “Itemized Equipment” and “Bulk Material”. Into the group “Itemized Equipment”, I had to create sub groups, split based on when these activities are scheduled (whereas in the department “Equipment”, equipments grouped together are similar equipment).

For example, the first group for electrical equipment is dedicated to “Long Lead Items” (a “Long Lead Item” is an equipment with a very long lead time).

6.2.3. Status of documents

These modifications are minors. Most of important deliverables are issued in three steps. The codification for these three steps in “EMC Data Sheets” is:

- First step: IFC = Issue For Comment
- Second Step: IFD = Issue For Design
- Third Step: FC = For Construction

This codification of deliverable status was adapted to SAIPEM SA codification:

- “IFC = Issue For Comment” replaced by “IFA = Issue for Approval”
- “IFD = Issue For Design” is not changed
- “FC = Issue For Construction” replaced by “IFC = Issue For Construction”

6.3. Linking activities

6.3.1. Approach

This is our earned value. The schedule we made is a typical document. As a consequence, durations of activities will be adapted to specifications of each project; activities can be duplicated depending on specific needs of the project, sequences for equipment will be distinct for each equipment…But if we want to convert this document into a real efficient tool which will be useful for planning engineers, we have to pay a special attention to the logic sequence of engineering.

The easiest way to link activities and to make a standard document is: create a “Start Milestone” for the contract award, link all activities to this milestone with a link “Finish to Start + lag”, with a quantity of time for the lag given by “EMC Index Form”.

Such a planning would be useless for the company. During execution phase, it makes any update impossible. As a consequence, it would just be a debased revision of “Engineering Management Class”, approved by the head office of SAIPEM.

To create a typical sequence of activities with logic links, it is required to:

- Understand activities, what are they about.
- Identify inputs/outputs of each activity.
- Identify kind of links to use, keeping in mind that the schedule will be updated, so taking into account the way an activity will impact another one.

6.3.2 An example: scheduling a typical sequence for engineering

6.3.2.1 Intra department Relationship

Intra department links for EMC TB03:

**Management Class: TB03 - Plot Plan and single line structure**

**Summary Description**
Definition overall plot plan, plant elevation, utilities and infrastructure

**Physical components**
Notes: forming group (C/O, O.E, code)

**Description of activities, incidence and duration**

<table>
<thead>
<tr>
<th>Management Class:</th>
<th>Plot Plan and single line structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities</td>
<td>General layout of plant and major components</td>
</tr>
<tr>
<td></td>
<td>Compatibility with all component information</td>
</tr>
<tr>
<td></td>
<td>Update with similar drawings</td>
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<tr>
<td></td>
<td>Update in development of engineering</td>
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<tr>
<td></td>
<td>Update as built</td>
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<td></td>
<td>Update in all information</td>
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</tbody>
</table>

**Priority constraints**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Predecessors</th>
<th>Events that must occur before/during activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLOT PLAN</td>
<td>IF C</td>
<td>Contractual issues, contacts with job management and Client - Plot plan (topographic survey) - Process flow diagram - List of units, utilities, utility locations</td>
</tr>
<tr>
<td></td>
<td>IF D</td>
<td>Specifications and process data sheets of items - Accessibility and layout constraints - Dimensions of components and packages - Preliminary grading plans and information from topographic and geotechnical investigations - Indicative layout of instruments and electrical layout and plant review meeting and client comments</td>
</tr>
<tr>
<td></td>
<td>IF E</td>
<td>List of drawings from vendors</td>
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</tbody>
</table>

**Activity | Successors | Events that influence other activities |
<table>
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</thead>
<tbody>
<tr>
<td>PLOT PLAN</td>
<td>IF C</td>
<td>The plot plan definition is a basic part of design and permits the development of Civil, Piping, Electric and Instrumentation engineering</td>
</tr>
</tbody>
</table>
“General layout of plant and major components”: first emission of plot plan.

   Predecessors: information from FEED.
   Link: “Finish to Start” with “Start Project Milestone”

“Completion with all components information”: second emission of plot plan.

   Predecessors: data from other department.
   Link: at inter department relationship step.

“Update with vendor drawing”: update of plot plan, with equipment drawing from vendors

   Predecessors: previous activity. The “Issue For Design” version is completed during this activity.
   Link: “Finish to Start” with the “Issue For Design” emission.

“Update with data of engineering”: the “plot plan” is the plan of plant and unit. During this phase, modifications on the plot plan, due to studies from other department are implemented on the plot plan. At this step of the project, changes on the plot plan are minors.

   Predecessors: data from other department.
   Link: at inter department relationship step.

“Update as built”: plot plan updated with data from construction.

   Predecessors: data from construction.
   Link: no link at this step.

“Single Line Structure”: definition of shape for “piperacks”, first emission.

   Predecessors: data from FEED and from other departments.
   Link: “Finish to Start” with “Start Project Milestone”.

“Completion with all information”: shapes of “piperacks” are finalized. Assessment of loads imposed to the “piperacks”. Status “IFD”.

   Predecessors: data from other department.
   Link: at inter department relationship step.
Intra department link for EMC TB04:

"Basic Layout": first emission of underground network layout. Status IFA.

Predecessors: “General Layout of Plant and Major Components”.

Link: “Finish to Finish”. Main underground piping lines are shown on the plot plan. That is why the first issue of underground network layout cannot finish before the first issue of plot plan.


Predecessors: “PID Mechanized” to size firewater networks. Previous activity, because it is an update of this deliverable.

Link: “Finish to Start” with “PID Mechanized” because it is a key input for this activity. Idem for “Basic Layout”.

“Update with vendor drawings and client comments”: third issue for this document.

Predecessors: second issue of underground network layout.

Link: “Finish to Start” with the Detailed Network.

“Update as Built”: underground network layout updated with data from construction.

Predecessors: data from construction.

Link: no link at this step.
"MTO 1": first material take off. Bill of quantities.

Predecessors: “Plot Plan”, “Specification of Piping Component”. The first MTO is a first appraisal of quantities. As we saw before, main piping lines are shown on the plot plan, which is a scale plan. “Specification of Piping Component” provides type of material required for piping.

Link: “Start to Start” with the second issue of plot plan. Information provided at this step is enough for a first appraisal. “Finish to Start” with “Specification of Piping Component”. These are key data to purchase material.

"MTO 2": second material take off. Update of previous activity.

Predecessors: second issue of “Plot Plan”. Same reason as mentioned above. “MTO 1”.

Link: “Finish to Start” with “MTO 1”. “Finish to Finish” with the second issue of plot plan. Modification and complement on the plot plan are taken into account for this second MTO.

Intra department link for EMC TB05:

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<th>Activity</th>
<th>Predecessor</th>
<th>Event that must occur before</th>
<th>Event that must occur during</th>
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</thead>
<tbody>
<tr>
<td>MTO 1</td>
<td>Plot Plan</td>
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</tr>
<tr>
<td>MTO 2</td>
<td>MTO 1</td>
<td></td>
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</tbody>
</table>

"Specification of Piping Component": activity aimed to define “Piping Material Class”, in which we can find piping material, corrosion allowance, limits for fluid pressure and temperature and kind of fluid.
Predecessors: data from “Process” and “Material” departments.
Link: at inter department relationship step.

“Valve Specification”: definition of valves type.

Predecessors: data from “Process”. “Specification of Piping Component”, because valves are set on piping, their specification depends on piping specification.
Link: “Finish to Start” with “Specification of Piping Component” because it is a key data for this activity. Data from process at inter department relationship step.

“Update with engineering and client”: update of “Specification of Piping Component” and “Valve Specification” following requirements from client and other engineering departments.

Predecessors: comments from engineering departments and client, “Specification of Piping Component” and “Valve Specification”.
Link: “Finish to Start + lag” with “Valve Specification”.

“Bids: control and technical appraisal”: technical evaluation of bids from vendors for piping components.

Predecessors: technical bids from vendors after “MTO 1 for piping components”.
Link: “Finish to Start + lag” with “Piping Bulk First MTO”.

“Bids for material not covered in previous agreement”: technical evaluation of bids from vendors for piping components.

Predecessors: technical bids from vendors after MTO 2 for piping components.
Link: “Finish to Start + lag” with “MTO 2 for piping components”.

“Technical appraisal for Motorized valves”: technical evaluation for “Piping” scope of motorized valves. Purchasing process for these valves makes part of “Instrumentation” scope.

Predecessors: data from “Instrumentation”.
Link: at inter department relationship step.

“Final Revision of Material Specification”: check and comments of drawings issued by vendors.

Predecessors: comments and drawings issued by vendors.
Link: “Finish to Start” with “Technical Evaluation” in the EMC Data Sheet TB06B, because this activity ends with the first “Purchase Order” for “Piping Components”, and consequently, the first issue of drawings by vendors.
Inter department links for EMC TB03:

“General layout of plant and major components”:

Predecessors: “Equipment List” and “PFD/UFD” from “Process” department.
Link: “Finish to Finish” with second issue of “Equipment List”. This list is not a key document to draw the first issue of plot plan, so “General layout of plant and major components” can start without this document. However, all major equipments must be on the first emission of plot plan; this is why there is this link. “Finish to Finish” with “PFD/UFD IFD”. “PFD/UFD” provides main connections between equipment and consequently, main piping lines.

“Completion with all components information”:

Predecessors: “PID/UID IFD” from “Process” department, and “Investigation Report” from “Civil” department.
Link: “Finish to Finish” with “PID/UID IFD”. “Finish to Finish” with “Investigation Report”. “Investigation Report” is the result of “Site Investigation” made by “Civil” department because this report includes topographic studies. Topographic data are available in the FEED. There are inputs for first issue of plot plan, and then, “Investigation Report” updates these data. That is why the link is “Finish to Finish”.

“Update with vendor drawings”: no inter department relationships.

“Update with data of engineering”: no inter department relationships.

“Update As Built”: idem.

“Single Line Structure”:

Predecessors: first issue if “PFD/UFD”, first issue of “Equipment List”.
Links: “Finish to Finish” for both activities. Same logic as the one used for “General layout of plant and major components”.

“Completion with all information”:

Link: “Finish to Finish” for “Investigation Report” and “PID/UID IFD” for the same reasons as mentioned above for “Completion with all components information”. “Fire proofing layout” mentioned structures which have to be protected against fire. “Fire proofing” is a superficial treatment applied on steel structure. This kind of protection is previous in the “Passive Fire Protection” strategy.
Inter department links for EMC TB04:

“Basic Layout”: no inter department relationships.

“Detailed Network”:

Predecessors: “Sewer scheme plan” from “Civil” department.

Links: “Finish to Finish”. Sewer networks are underground networks, under “Civil” responsibility. They are implemented into “Underground network layout” by “Piping” department.

“Update with vendor drawings and client comments”:

Predecessors: “Main Foundation Layout” from “Civil” department.

Links: “Finish to Finish”. “Main foundation Layout” is an input data for “Underground Network Layout” because it is a tool to manage clash between underground piping lines and foundations.

“Update with engineering activities”: no inter department relationships.

“Update as built”: no inter department relationships.

“MTO 1”: no inter department relationships.

“MTO 2”: no inter department relationships.

Inter department links for EMC TB05:

“Specifications of piping components”:


Links: “Finish to Start” with “Material Selection Diagram” because it is a key input to realize “Piping Material Class”, which is the deliverable issued by this activity. “Start to Start” with “PID/UID IFD” because “PID/UID IFD” feeds “Piping Material Class” with data relevant to properties of processed fluid.

“Valve specifications”:

Predecessors: idem.

Links: idem.

“Update with engineering and client”: no inter department relationships.

“Bids: control and technical appraisal (for piping components)”: no inter department relationships.
“Bids for materials not covered in previous agreement”: no inter department relationships.

“Technical appraisal for motorized valves”:


Link: “Finish to Start” with “Technical Evaluation” from “Instrumentation”. “Piping” is involved in purchasing process for “Motorized valves” because of the interaction between valves and piping lines.

“Final revision of material specifications”: no inter department relationships.

6.3.3. Conclusion

We have just seen an example what we did for all engineering activities.

6.4. Implementation into Primavera P6

Here is an example of activities described above, links implemented in “Primavera P6” are those mentioned above:

<table>
<thead>
<tr>
<th>Activity ID</th>
<th>Activity Name</th>
<th>EMC Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>U00ETB03X-7006</td>
<td>Plot Plan (IFD) Completion with all components information</td>
<td></td>
</tr>
<tr>
<td>U00ETB03Y-9006</td>
<td>Plot Plan (update) Update with development of engineering</td>
<td></td>
</tr>
<tr>
<td>U00ETB03Y-6006</td>
<td>Plot Plan (IFC) Update with vendor drawings</td>
<td></td>
</tr>
<tr>
<td>U00ETB03W-8006</td>
<td>Plot Plan (IFA) General layout of plant and major components</td>
<td></td>
</tr>
<tr>
<td>U00ETB03Z-9406</td>
<td>Plot Plan (As Built) Update as built</td>
<td></td>
</tr>
<tr>
<td>U00ETB03-6506</td>
<td>General Layout / Plot Plan Issued for Design Not Applicable</td>
<td></td>
</tr>
</tbody>
</table>

DEPARTMENTS FOR EMC: PIP.TB.03 Plot Plan & Single Line Structure

<table>
<thead>
<tr>
<th>Activity ID</th>
<th>Activity Name</th>
<th>EMC Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>U00ETB04Y-9008</td>
<td>Underground Networks (update) Update with engineering activities</td>
<td></td>
</tr>
<tr>
<td>U00ETB04W-8008</td>
<td>Underground Networks (IFC) Update with vendor drawings and client coments</td>
<td></td>
</tr>
<tr>
<td>U00ETB04Y-9008</td>
<td>Underground Networks (IFA) Basic layout</td>
<td></td>
</tr>
<tr>
<td>U00ETB04X-7008</td>
<td>Underground Networks (IFD) Detailed network</td>
<td></td>
</tr>
<tr>
<td>U00ETB04-3010</td>
<td>Underground Networks MTO2 Update material take off</td>
<td></td>
</tr>
<tr>
<td>U00ETB04-3009</td>
<td>Underground Networks MTO1 Material take off</td>
<td></td>
</tr>
</tbody>
</table>

DEPARTMENTS FOR EMC: PIP.TB.04 Underground Networks

<table>
<thead>
<tr>
<th>Activity ID</th>
<th>Activity Name</th>
<th>EMC Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>U00ETB05-1014</td>
<td>Final Revision of Material Specification Final revision of material specifications</td>
<td></td>
</tr>
<tr>
<td>U00ETB05-1013</td>
<td>Update Specification with Engineering &amp; Client Update with engineering and client</td>
<td></td>
</tr>
<tr>
<td>U00ETB05-1012</td>
<td>Valves Specifications Valve specifications</td>
<td></td>
</tr>
<tr>
<td>U00ETB05-4011</td>
<td>Bids for material not covered in previous agreement Bids for materials not covered in previous agreement</td>
<td></td>
</tr>
<tr>
<td>U00ETB05-4012</td>
<td>Bids Control &amp; Tech Appraisal (piping component) Bids control and technical appraisal</td>
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<tr>
<td>U00ETB05-4013</td>
<td>Technical Appraisal for Motorized Valves Technical appraisal for motorized valves</td>
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<tr>
<td>U00ETB05-1011</td>
<td>Specifications of Piping Component Specifications of piping components</td>
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</tr>
</tbody>
</table>

DEPARTMENTS FOR EMC: PIP.TB.05 Materials Specification

“General layout / Plot plan issued for Design” is a significant milestone for project execution, it is not scheduled in EMC Data sheets. Some “Activity Name” had been changed to be meaningful and to put forward the status of deliverables issued.

Our typical schedule is the result of that kind of thought, for more than seven hundreds activities.
Here is the schedule of all activities described above, after implementation into “Primavera P6”.

<table>
<thead>
<tr>
<th>Activity ID</th>
<th>Activity Name</th>
<th>Start Date</th>
<th>End Date</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>U06TB06-6000</td>
<td>Plot Plan (IFC)</td>
<td>01-Jun-12</td>
<td>12:00 PM</td>
<td>PIP TB Piping</td>
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<tr>
<td>U06TB06-6500</td>
<td>General Layout: Plot Plan Issued for Design</td>
<td>01-Jun-12</td>
<td>12:00 PM</td>
<td>PIP TB Piping</td>
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<tr>
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<td>PIP TB Piping</td>
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<tr>
<td>U06TB06-8000</td>
<td>Plot Plan (update)</td>
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<tr>
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<tr>
<td>U06TB06-9040</td>
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<td>U06TB04-3000</td>
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<tr>
<td>U06TB04-7000</td>
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<td>PIP TB Piping</td>
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<tr>
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<td>12:00 PM</td>
<td>PIP TB Piping</td>
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</table>
7. Approval process

7.1. Mutual check into the trainees team

As explained before, we worked together to link activities on “Gantt Diagrams” (paper support), we just split it to implement into the software “Primavera P6”. So each member of the team had to implement his part into the software, and then, each member had to check the work of other members of the team.

This first step of checking process is basic, we just checked if all “Gantt Diagrams” are correctly implemented in the software.

7.2. Critical Path Analysis

This is the second step of confirmation of the job we made. In this step we had to analyze the sequence of activities on the critical path.

The goal with this analysis is to ensure that all activities on the critical path are significant activities with a real impact on project’s progress. Thus, we make sure the typical schedule proposed is adapted to progress control and consistent with the execution of a project.

![Gantt Chart Image]

After a few corrections, we finally got the critical path shown above. Even if critical path is mostly significant for EPC Projects (Engineering Procurement Construction), in our case, it is a good way to assess consistency of our schedule. We can see that engineering duration depends on “Piping” activities: “Plot Plan”, 3D Underground Network”, “3D Model” and “Isometrics”. These activities are both important for engineering and construction, there are really significant for the physical progress of the project. Thus, we can conclude that main engineering activities logics are respected in our schedule.
7.3. Approval by engineering discipline leaders

This is the final stage of typical schedule approval process.

Engineering discipline leaders are people with the best skills to check typical logic sequence of their disciplines. Besides, as we planned their job, they have to approve it.

Moreover, the schedule we made is a standard document, it is a new tool. Approval by engineering discipline leaders should make easier it passing among planning engineers from the project control department. It is a new step to convert this standard document into an efficient tool.

To conclude, this final step of process approval is the most important for our job. There are two goals: make sure this schedule is right, give it credibility and convert this document into a useful tool for the “Project Control” department of SAIPEM SA.

8.1. **Purpose of this document**

This document is an update of an existing document “Handbook for planning engineers, v0”. It is aimed at junior engineers, from project control department or from any other department. It is a training tool for everyone who needs to develop his technical culture for oil and gas industry. We can find in this document:

- Explanation of main engineering activities for each department
- Explanation of relationships intra and inter departments
- Special emphasis on main engineering logics

The “Handbook for planning engineers” is an intermediary document between a junior planning engineer and the engineering typical schedule.

8.2. **Changes from “Handbook for planning engineers, v0”**

For this second issue of the handbook, the technical content had been enriched with more explanations, extracts from typical documents when they are mentioned and matrix to summarize logics between main documents issued by engineering department.

Besides, I put a special emphasize on exchanges between engineering departments for a same document. Here is an example, for the realization of “Single line structures for piperack”:
### Piping

- Racks shape
- Positioning of piping and cables on racks
- Evaluation of loads imposed on racks

### CIV / Steel Structure

- Racks sizing
- Reinforcement sizing
- Selection of steel structure profiles
- Evaluation of loads transmitted to the foundations
Example of a matrix “Intra department links” for “Piping”:

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## Matrix "Inter department links":

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<th>Inter disciplinaire</th>
<th>LPE</th>
<th>Instrumentation / INS</th>
<th>Piping / PIP</th>
<th>Electrical / ELE</th>
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### LPE
- Specification for Supervision & Control System
- Specification for Safety, Alarm & Automation Systems
- Specification for Process Simulator
- Specification for metering system
- PID/UID Mechanized
- Plot Plan
- Single Line Structure
- Line Specification / PMC
- Valve Specification
- 3D Model
- Valves MTO
- Electrical System Design Basis Specification
- Power cable sizing calculation
- Electrical General single line diagram
- Substation single line diagram
- Substation layouts and arrangement drawings
- Cable run layout
- Process & Ut. Data Sheets for valves
- Overall tables of vent to flare and blowdown
- Fire Fighting Eqp Data Sheet (valves included) UID (F&G)
- Cause & Effect Matrix (F&G)
- Fire & Gas detector layout drawings
- HAZOP (F&G) SIL (F&G)
- Hazardous Area Classification
- Site investigation report
- Demolition Layouts
- Structure Single Line HVAC Diagram
- Foundation plan
- Architectural Final Layout for buildings
- Underground Layout

### Instrumentation / INS
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The philosophy of this new issue of the “Handbook for planning engineers” is to make it easier to read and easier to understand.

Contrary to the previous issue, I tried to make each chapter of the handbook understandable, with independence of other chapters. The purpose of this new issue is to encourage people to use it, for example if they quickly want to check information, and to make them feel free to enrich it.

Another strength of this new issue is to group one example of all standard documents (PID, General Single Line Diagram…) in the same document. This way, the reader can find in the same document:

- List of all main engineering documents and activities
- Logics between all these main engineering activities
- Explanation of these activities
- Example of each engineering standard document
9. **Achievement of initial objectives and possible improvement**

9.1. **Initial goal and “Typical Schedule for Engineering”**

I think we have fulfilled our initial requirements making a schedule for all engineering departments. However, we had to group and summarize activities (for “Equipment” and “Electrical” department). As a consequence, our document is not an exhaustive list of engineering activities, planning engineers will have to adapt our sequences to specificities of each project.

Besides, it is early to qualify the success of our job because it has never been used on real projects. Thus, I think this first issue of “Typical Schedule for engineering” will be updated later, to make easier its use and make it more consistent with schedules for real projects.

9.2. **Planning and resources**

We have not assigned any resources into our schedule. In execution phase, budgeted hours for each activity are key data to create “Progress S-Curves”. These curves are “Project Control” tools to compare real progress with planned progress.

It would be interesting to benchmark budgeted hours for main engineering activities of onshore projects achieved by Saipem and to implement the results of this benchmark into our typical schedule.

This way, we would be able to find in our tool typical logic sequences for engineering and typical progress curves.

9.3. **“Typical Schedule for Engineering – Procurement – Construction Projects”**

We have just scheduled the first phase of EPC Projects realized by Saipem. In our schedule, we cannot assign successors for several activities because we just have engineering activities. For example, most of “Equipment” department’s activities are linked to procurement activities. We were not able to link these tasks.

More over, because of relationships between engineering, procurement and construction, the critical path we analysed to assess consistency of our schedule will be modified (even for engineering activities) adding procurement and construction phases. It will be a significant indicator.
10. Economic Analysis

10.1. Price estimation for “Engineering Typical Schedule”

Basically, two kinds of resources were used to make this schedule:

- Man hours
- Software “Primavera P6”

Three trainees worked on this project. François Raoult worked on it during eight months (full time), I worked on it during 4 months (full time) and Pauline Robin dedicated it 3 months (full time). Each trainee is paid 900 euro a month, so a first estimation of this schedule would be:

\[(4 + 3 + 8) \times 900 = 13500 \text{ euro}\]

Besides, two of us had a license for the software “Primavera P6”, which costs 1500 euro.

Thus, the overall cost of this project is: 16500 euro.

However, this first price valuation does not include contribution of engineering department leaders, who spent many hours helping one of us (François Raoult) to write the first issue of the “Handbook for planning engineers, v0”. Beside, hours spent to manage our project by Olivier Nègre (planning department manager) are not included into this estimation.

10.2. Benefits

It is not easy to assess benefits of this continual improvement process. This typical schedule will help planning engineers to be faster and to propose a detailed schedule in bidding phase, which is a good point for the company.

Besides, during project’s realization, typical schedule will be a reliable basis to be faster to schedule typical sequences. Thus, planning engineers will have more time to dedicate to critical points of the project.

Finally, we can imagine that communication between all departments involved in the project will be improved because the typical schedule will be approved by all of them.
11. **Environmental Analysis**

11.1. *Environmental Impact Assessment of my project*

The main environmental impact of my project is the use of consumable. Indeed, I needed to print about 500 sheets of paper.

Besides, to come to the office, I had to take a train two times a day, 5 days a week. As I dedicated 4 months of my internship to realize this project, my carbon footprint for this project is:

- 58 g of CO2 for each trip
- 2 trips a day
- 5 days a week
- 4.5 weeks a month
- 4 months for this project

Finally, my carbon footprint is: 10.44 kg

11.2. *Onshore projects and environment*

Environmental engineering is grouped with “Fire Protection” into the department “Loss Prevention Engineering”. The main purpose of environmental engineering is to reduce project’s environmental impacts, through environmental studies. Environmental studies are made of air pollution, water pollution and noise studies.

Moreover, “Environmental and Social Impact Assessment” is a key step for the project. This a required document (scheduled on six months) to start construction. This study must include specificity of each area and comply with local and international legislation.

Actually, gas liquefaction projects are most important projects in the Oil& Gas industry. This is a cleaner energy than petroleum, and liquefied, it is one of the most economic way to transport energy.
Conclusion

We have reached our goal in achieving the “Typical schedule for engineering”. We have scheduled more than 700 activities, including typical logic sequences of engineering activities. This document is now an efficient tool which must be adapted to specificities of each onshore project. This planning could be filled out with scheduling of “Procurement” and “Construction” phases.

I am very satisfied with this experience. I have discovered a very interesting job and I think I have reached the objective of this internship: make an efficient tool for Saipem. I liked both technical and managerial content of the job. As we had a good autonomy to reach our goal, we had to manage our project. It was the first time I had to manage a several months project with a team in a working environment. I enjoyed this working experience to identify my strengths and weaknesses. Moreover, I was lucky to work with high skilled professionals, who helped me during this project.

As I expected, this internship was a very good opportunity to use my academic knowledge in a professional environment, and a good transition to start my future career.

Acknowledgement

I especially want to thank Mr Olivier Nègre, who is the head of planning section in Saipem, and who was also my supervisor, for his contribution to the success of the “Typical schedule for engineering” project.

I want to thank you Mr Francis KY as well, Mr Alexandre LAROSE, and all planning engineers of Saipem for their useful advices and recommendations.
Appendixes

Appendix A - “Handbook for planning engineers, v1” (Piping section)

III Piping department

PIP

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| Liste des documents      |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| PID/UID Mechanized       |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| Line List                |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| Plot Plan                |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| Single Line Structure    |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| Single Line Drawings & Ladders | |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| Line Specification       |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| Valve Specification      |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| Preliminary Routing      |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| MTO 1                    |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| MTO 2                    |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| MTO 3                    |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| 3D Model                 |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| ISO                      |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| Piping Arrangement       |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| Stress Analysis Report   |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| Valves MTO               |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
| UDD                      |                    |           |          |                       |                               |                  |                   |                   |       |       |       |           |     |                   |                        |            |     |
B. « Plot plan » and « Single line »

Geographical organization of the plant is under « Piping » responsibility. This goal is reached through the issue of layouts called “Plot Plan”. We can find several kinds of “Plot lan” :

- « Overall plot plan » or “General plot plan” : global map of the plant on which we can find units, buildings, equipments and main steel structures.

![Example of « Overall Plot Plan »](image)

- « Unit Plot Plan » or « Equipment layout » : map of a single unit on which we can see equipments, maintenance zone...

![Example of « Unit Arrangement Plot Plan »](image)

Sometimes, these documents are extracted from the FEED (Front End Engineering Design) and developed later.
« Key Plan » is a geographical breakdown of the plant designed from « Plot Plan ». “Key Plan” is an input for the 3D model. “Piping” department has to make this document which is a necessary document for other engineering departments.

« Piping » department is responsible for the « Pipe Rack Single Line Diagram ». « Pipe Rack » is a structure (steel or concrete) designed to support piping and cables. “Piping” engineers design shape of the racks and they estimate the loads on the rack. Then, these data are transferred to “Civil” department who will design steel structure.
C. « 3D model »

This is a computerized model of the plant which shows all units, piping and equipment arrangement. We can find on this computerized model routings for all pipe lines. It is designed thanks to the software PDS (Intergraph) or the software PDMS (Aveva).

The functions of the « 3D Model » are: make easier clash management (between pipe lines, pipe racks...) and coordination between engineering departments. For the client, it can be a training tool for operators and a tool for maintenance as well. There is just one “3D Model”, and each department can work on it.

« 3D Model » design starts with the beginning of engineering studies, with the issue of « Preliminary routings ». Main inputs of this “3D Model” are the several issues of PID/UID (Issue For Comments, Issue For Design, Issue For Construction) and vendor’s data for arrangement of equipments (nozzle orientation...). Once « 3D Model » is achieved, client can use it as a training tool for operators or as a maintenance tool.

« 3D setting » takes into account interface with MARIAN, a material management software. “Piping Material Classes” are created through “MARIAN” and then related with 3D Model. This is how bill of quantities for piping material are created.
Example of « Piping Material Class »

From « 3D Model » we can update « Plot Plan », if major changes have been realized (most of the time, because « vendor data » about equipment arrangement.

D. « Preliminary routing » et « Preliminary stress »

“Preliminary Routing” is a 2D layout of main pipe lines routings. It is issued before freezing “Unit Plot Plan”.

Example of « Preliminary routing »
« Preliminary Routings » can impact « Structure Single Line drawings » and activities from “Civil” department. Once “Preliminary routings” are converted into “3D Model”, this computerized model will be the basis of piping stress studies. First routings realized are “Underground routings”.

« Preliminary stress » studies are useful to freeze routings for main critical pipe lines. These studies depend on design factors like fluid temperature, fluid pressure, snow, wind...

« Preliminary routings » and « Preliminary stress analysis » are linked.

For example, stress calculation can impose expansion loops on a piping line. An expansion loop avoids irreversible deformation and risk of fracture of piping, due to dilatation or shrinkage (fluid temperature variation).


**E.  « PID, UID mechanization »**

« PID/UID Mechanization » is the step of engineering when each department (Piping, Instrumentation, Equipment) adds its own comment on PID/UID. « Process » department is responsible for this activity. PIP adds into PID data from « Plot Plan », bill of quantities...

**F. Isometrics**

An « Isometric » is a 3D layout useful for piping pre fabrication. This document is quoted but it is not a scale drawing. It is extracted from the “3D Model”. We can find on these layouts specific information for piping erection. The only relevant status for an isometric drawing is “Issue For Construction”.

*Extrait d’un « Isometric Drawing »*
To start issue of isometrics, PID/UID must be issued in the phase « Issue for Construction ». “3D Model” is updated until all pipe lines arrangement are defined.

While isometrics drawings are issued, piping supports are designed and there are all grouped into a « Support booklet ». Besides, in the same time, a layout showing all pipe lines arrangement, “Piping General Arrangement” is issued.
G. « Material Take Off » (MTO)

A « Material Take Off » is a bill of quantities for bulk material (material which is not itemized like cables, pipe lines, steel structure...). These “bill of quantities” are useful to start « Invitation to bid », to issue “Purchase orders” and to manage quantities. Manual valves are considered as “Bulk material”. Basically, there are three steps for this activity, which last about 15 months.

To make the first MTO, PID/UID “Issue for Approval” are required. For example, we can find on it how many manual valves are necessary for process loops. To quantify piping material, “Preliminary routings” are required.

To update the first MTO (and issue MTO2), second issue of PID/UID (PID/UID Issue For Design) and an update of preliminary routings are required.

Average required time to realize a « Material Take Off » is two months. The last issue of « Material Take Off » requires much more time because it is based on isometrics drawings issue.
H. « Piping Arrangement »

Once « Plot Plan » and « 3D Model » have been issued, « Piping » department has to design “Piping Arrangement”. This document is required for piping erection on field.

Besides, « Piping department » has to design piping supports, valves, ladders and secondary structures.

I. « Utility Distribution Diagram » (UDD) & line list

The goal of this activity is design utilities distribution network. Its inputs are PID/UID from process.
## Appendix B – “Typical Schedule for engineering”

### TYP MIL. Typical milestones

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<td>HAZOP Review report first issue</td>
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<td>PFD issued for construction</td>
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### PCS Process

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### Notes

- Remaining Work
- Critical Remaining Work

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#### EQP Equipment & Packages

| EQP PK Process Packages & Handling                  | 375.04       |      |
| Technical Specification for PK                      | 21.00        |      |
| Material Requirement for PK                         | 10.00        |      |
| Technical Evaluation for PK                         | 21.00        |      |
| Technical Documentation Issue for Order for PK     | 21.00        |      |
| Vendor Doc Follow up for PK                          | 270.00       |      |

| EQP GL Pressure Equipment                           | 374.04       |      |
| Material Requirement for GL                         | 21.00        |      |
| Technical Evaluation for GL                         | 35.00        |      |
| Technical Documentation Issue for order for GL     | 21.00        |      |
| Vendor Doc Follow up for GL                          | 280.00       |      |

| EQP FR Furnaces                                     | 393.04       |      |
| Technical Specification for FR                      | 10.00        |      |
| Material Requirement for FR                         | 10.00        |      |
| Technical Evaluation for FR                         | 21.00        |      |
| Technical Documentation Issue for Order for FR     | 12.00        |      |
| Vendor Doc Follow up for FR                          | 250.00       |      |

| EQP PE Energy Packages                              | 394.04       |      |
| Material Requirement for PE                         | 21.00        |      |
| Technical Evaluation for PE                         | 21.00        |      |
| Technical Documentation Issue for Order for PE     | 21.00        |      |
| Vendor Documents Follow up for PE                   | 250.00       |      |

| EQP MM Rotating Equipment                           | 403.04       |      |
| Technical Specification for MM                      | 22.00        |      |
| Material Requirement for MM                         | 21.00        |      |
| Technical Evaluation for MM                         | 21.00        |      |
| Technical Doc Issued for Order for MM              | 21.00        |      |
| Vendor Doc Follow up for MM                          | 270.00       |      |

| EQP SC Shell & Columns                              | 348.04       |      |
| Thermal Design for SC                               | 21.00        |      |
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| Vendor doc Follow up for SC                          | 210.00       |      |

| PIP Piping & Layout                                  | 546.74       |      |

| PIP TB Piping                                        | 515.34       |      |

#### PIP TB 02A Process P&ID Mechanization

| PIP TB 02A Process P&ID Mechanization                | 357.03       |      |
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| Process P/I Mechanization (FOD)                     | 75.00        |      |
| Process P/I Mechanization (FC)                      | 64.00        |      |
| Process P/I Mechanization (update)                  | 103.00       |      |

| PIP TB 03 Plot Plan & Single Line Structure          | 454.04       |      |
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| Single Line Structure IFA                           | 56.00        |      |
| Single Line Structure FOD                           | 150.00       |      |
| Plot Plan (FOD)                                     | 195.00       |      |
| Plot Plan (IFC)                                     | 107.50       |      |
| Plot Plan (update)                                  | 120.00       |      |

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*Critical Remaining Work*

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**INS Instrumentation**

| INS.AS.02 Instrumentation             | 523.0%        |      |
| INS.AS.01 PID & Loop Data Sheet       | 397.0%        |      |
| Instrument Data Base (Data entry)     | 334.0%        |      |
| General Specification (IFC)           | 35.0%         |      |
| PID Mechanization (IFC)               | 95.0%         |      |
| General Specification (IFC)           | 95.0%         |      |
| PID Mechanization (IFC)               | 105.0%        |      |
| INS.AS.03 Control, Motorized & Safety valves | 407.0% |      |
| Quality / Technical Spec for A502 (IF3) | 60.0% |   |
| Data Sheet & Calculation for A502 (IF3) | 191.0% |   |
| Quality / Technical Spec for A502 (IF3) | 42.0% |   |
| Technical Evaluation for A502         | 95.0%         |      |
| Data Sheet & Calculation for A502 (IFC) | 95.0% |   |
| Vendor Doc Follow up for A502          | 103.0%        |      |
| Quality / Technical Spec for A502 (IFC) | 95.0% |   |
| INS.AS.04 Measurement & Control Instrument | 203.0% |      |
| Quality / Technical Spec for A503 (IF3) | 67.0% |   |
| Data Sheet & Calculation for A503 (IF3) | 120.0% |   |
| Quality / Technical Spec for A503 (IF3) | 42.0% |   |
| Technical Evaluation for A503          | 105.0%        |      |
| Vendor Doc Follow up for A503          | 205.0%        |      |
| Data Sheet & Calculation for A503 (IFC) | 95.0% |   |
| Quality / Technical Spec for A503 (IFC) | 95.0% |   |
| INS.AS.05 Analysers Systems           | 307.0%        |      |
| Quality / Technical Spec for A504 (IF3) | 42.0% |   |
| Data Sheet & Calculation for A504 (IF3) | 43.0% |   |
| Quality / Technical Spec for A504 (IF3) | 34.0% |   |
| Technical Evaluation for A504          | 95.0%         |      |
| Vendor Doc Follow up for A504          | 200.0%        |      |
| Data Sheet & Calculation for A504 (IFC) | 21.0% |   |
| Quality / Technical Spec for A504 (IFC) | 20.0% |   |
| INS.AS.06 Supervision & Control Systems | 438.0% |      |
| Technical & Detailed Technical Spec for A505 | 237.0% |   |
| Technical Evaluation for A505          | 44.0%         |      |
| Vendor Doc Follow up for A505          | 103.0%        |      |
| Factory Acceptance Test (FAT) for A505  | 56.0%         |      |
| INS.AS.07 Safety, Alarm & Automation System | 309.0% |      |
| Functional & Detailed Technical Spec for A506 | 235.0% |   |
| Technical Evaluation for A506          | 44.0%         |      |
| Vendor Doc Follow up for A506          | 205.0%        |      |
| Factory Acceptance Test (FAT) for A506  | 43.0%         |      |
| INS.AS.08 Process Simulators           | 309.0%        |      |
| General Spec for A508                   | 23.0%         |      |

Date Révision Vér. Ap. Planning Type EPCC Onshore_TEST v1
### Engineering Typical Schedule

**INS.AS.09 Installation Drawings & Materials**

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**ELE.LAY.03F Protection Relay Setting Studies**

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**ELE.LAY.03G Electrical Substations Layouts**

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**ELE.LAY.19H Lighting Layouts**

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**ELE.EQP Electrical Equipment**

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**ELE.BLK Electrical Bulk**

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**Legend:**
- Remaining Work
- Critical Remaining Work

**Planning Type:** EPCC

**Onshore TEST v1**
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Remaining Work:  
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Date: 03-  
Revision: 1st Issue  
Ver: 0  
Planning Type: EPCC  
Onshore: TEST v1
Bibliography


*Engineering Management Class*, Corporate document