Universitetet
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**FACULTY OF SCIENCE AND TECHNOLOGY**

# MASTER'S THESIS

| Study programme/specialisation: Industrial Asset Management | Spring / Autumn semester, 2018<br><br>Open/~~Confidential~~ |
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| Author: Mehdi Akbarzadeh | ................................<br>(signature of author) |
| Programme coordinator: Professor Jayantha.P. Liyanage, PhD<br><br>Supervisor(s): Dr. Christof Schätz | |
| Title of master's thesis:<br><br>Human resources planning, allocation and scheduling method in complex multi-project environment | |
| Credits: 30 | |
| Keywords:<br>• Multi-project environment<br>• Scheduling<br>• Human resource planning and allocation<br>• Primavera P6 ™<br>• Gap Analysis | Number of pages: 97<br>+ supplemental material/other: 0<br><br>Stavanger,15/06/2018<br>date/year |

Title page for Master's Thesis
Faculty of Science and Technology

# Abstract

Human resource is one of the main assets of a companies. In the companies with a multi-project environment, effective and efficient allocation of scarce human resources has great importance. In these companies, project managers and human resource managers are often struggling to allocate constraint human resources over projects in the execution phase. To optimize project performance, increase the quality and prevent delays, it is important to assign human resource with right expertise, competence and availability to each project while considering the project's benefit, strategic value, initial costs, and so on. To achieve this, it is recommended that the case company implement critical elements of human resource's allocation process which is in line with the case company's business plan. These elements are long-term, medium-term and short-term. They are linked together and the feedback is evaluate yearly (Hendriks et al., 1999). Such plans enable managers to achieve a balance between human resource's availability and project demands.

Despite an immense amount of research carried out about project management and project scheduling, many projects around the world still finish later than expected and with higher cost. According to Demeulemeester and Herroelen (2009), one of the main causes of this failure is ineffective project planning and scheduling. Many companies with a multi-project environment are using available commercial packages for the project scheduliung. The softwares utilized typically include the Critical path method (CPM) approach to calcuate project duration and finish time, which does not consider resource issues in the scheduling. The second reason for ineffective project scheduling is focusing on the deterministic setting which assumes activities duration and human resources availibility are know with certainty. However, in reality all the projects encompass a high degree of uncertainties. To manage project uncertainties and increase project planning and scheduling efficiency, it is recommended that the case company identifies all uncertainties of each project at the beginning of the project, while ranking them and adopting preventive measures when needed.

To consider resource constraints in project scheduling, it is recommended to generate a simple, useful and reliable human resource database as a powerful tool beside Primavera™ [1] . This will give managers a more accurate human resource availability for short-term and medium-term forecast.

[1] commercial package the case company use for project scheduling

## Acknowledgements

First of all, I would like to express my thanks to my thesis supervisor Professor Jayantha.P. Liyanage from the Industrial Asset Management department at University of Stavanger. I have received a lot of excellent and kind advice from him throughout my Master thesis, specifically when I had questions relating to my thesis. He consistently allowed this thesis to be my own work, but helped me to find the right direction when I got off track. Also, I would like to take this opportunity to thank him for being a great support during my Master.

I would also like to give special thanks to Dr. Christof Schätz who was involved as my co-supervisor in this research project. He helped me to define a challenging topic. Having regular meeting with him helped me to learn a lot about human resource planning and allocation in multi-project environment and cause the project to stay on track. Without his passionate participation and input, this master thesis could not have been successfully completed.

Finally, I must express my profound gratitude to my wife Rihanna Ghahremani for providing me with unfailing support and continuous encouragement throughout my years of study and throughout entire the process of researching and writing this thesis. This achievement would not have been possible without her support and patience. Thank you.

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# 1 Introduction

## 1.1 Background

Due to increase of current business environment complexity, project managers need to assign scarce human resources efficiently over the projects in execution and make quick decisions, especially in the companies which handle multi- projects. This cause challenges for project managers since they have different projects with different scopes, timelines and complexities at the same time. Often insufficient balancing of scarce human resources lead to additional pressure on a company (Caniëls and Bakens, 2012).

Usually project managers in multi-project environment use several pools of scarce human resources that they must share with other project managers (Caniëls and Bakens, 2012). Using several pools of human resources at the same time throughout different projects can make conflicts among projects involved. These conflicts should be measured and prioritized. Although sharing these pools may increase human resources efficiency by reducing idle time and sharing of experience and knowledge, there is always an important risk which can threaten this environment. This associated risk may include having a problem in one project effect the other project(s) negatively (Caniëls and Bakens, 2012). When one project has a delay on its activities, the ongoing will be cumulatively loaded on human resources and will add unnecessary pressure and may increase their workload in a short period of time. In such a situation, requirements for valid planning and control are not met. Therefore, these interactions and interdependencies of projects which are key factors in a multi-project environment must be managed by project managers. As a result, there is a need to generate systematic project planning and control to make this situation more predictable. To achieve this, project planning and scheduling, monitoring and control and human resources management of projects should be integrated (Caniëls and Bakens, 2012).

Balance between project demands and human resource availability is also an important challenge for project managers in multi-project environment. Project overload is a common problem which often leads to over commitment of project with allocated human resources. Project overload result in a negative impact on project time, scheduling and quality of work. To avoid such a problem, it is necessary to make a balance between project demand and human resource availability (Caniëls and Bakens, 2012). This challenge can be resolved by generating a Project Management Information System (PMIS), which is required to be continuously updated. PMIS should provide decision making support for project managers in planning, organizing and controlling of the project (Caniëls and Bakens, 2012). Routines and procedures can be helpful when there is a project overload situation. This allows the project team to know how the work must be done and what to do. However, there should be a balance in number of routines and procedures. Too many procedures lead to administrative problems which can shift attention from the actual project management tasks to procedural activities. On the other hand, too few routines can increase uncertainties about what to do next in project. In a multi-project environment, the schedules of different projects might be dependent on each other. Information about human resource availability at every moment is essential for project progress and success. However, a multi-project environment is characterized by lack of quality of project information and inadequate information transparency. It is found that quality of project information input is directly effect on quality of decision making (Caniëls and Bakens, 2012). In general, inadequate information leads to poor decision-making (Caniëls and Bakens, 2012).

In any projects, decision-making is one of the important responsibility of a project manager which can cause project failure or success (Marques et al., 2010). Many times by increasing the volume of data (for example the uncertainties and contributions of effective factors in project), the level of complexity will get higher and decision making will become more complicate and difficult (Marques et al., 2010). In these situations, it is essential that project managers apply professional tools, skills, knowledge and methods to find proper solutions to overcome problems and challenges, such as human resources allocation and scheduling during a project life time (Marques et al., 2010).

In addition, organizations should regularly perform an analysis of the current situation by measuring and assessing the strengths and weaknesses, and researching the alternatives and solutions. To do so, the organization will create and implement processes, and update the gap analysis. This involves setting up meetings with colleagues and managers, interviewing them about the weaknesses and challenges in current situation, and gathering information from database and internal documents. This information helps to explain and identify problems and challenges that the company may be facing. Also, it helps to identify a gap between what is expected and what has really been completed. Gap analysis is the technique to identify the areas which need to be improved in any process, system, policy and even the corporate strategies and culture. It helps ensure to keep it on the right track. It is about finding a gap between desired performance and actual performance. This gap analysis could be used in any company and in any businesses (Chhetri, 2018).

Much research has been done about project scheduling problems since end of 1950s. This has led to an extensive amount of literature (Demeulemeester and Herroelen, 2009). Moreover, a variety of different commercialized project management software has been released and applied by companies. However, there is evidence of many projects which finished widely over budget or finished much later than the scheduled plan (Demeulemeester and Herroelen, 2009).

Finishing project on time, within budget and based on the defined scope, continues to be difficult. One of the main causes of these failures can be ineffective project planning and scheduling (Demeulemeester and Herroelen, 2009).

One of the main reasons for inefficient project planning and scheduling is little attention of project management professional to the importance of Human Resource Constrained Project Scheduling Problem (RCPSP) (Demeulemeester and Herroelen, 2009). Most of popular project management text books discuss the concept of *temporal scheduling* (using Critical Path[2] Method (CPM) or Project Evaluation and Review Technique (PERT) to compute the earliest and the latest start times and slack values of project activities), without deep considering of human resources scheduling issue (Demeulemeester and Herroelen, 2009).

In practice, many companies use available commercial project planning software which utilize the simple critical path methodology focusing on the longest path in the project network. The baseline schedule reflects the activities' planned start times which calculated as a result of the longest path computation. This depends on the planned duration of the project activities and their sequences determined by precedence relations in the project network (Demeulemeester and Herroelen, 2009).

The other important reason behind inefficient project planning and scheduling is that most of research literature on constrained project scheduling focuses on *deterministic* setting. This concept assumes that the human resource availabilities, requirement and activity durations are known with certainty (Demeulemeester and Herroelen, 2009). However, projects are often subject to considerable uncertainty during their execution time which can lead to many schedule disruptions. It became obvious to researchers in recent years that uncertainty lies in the heart of project planning, and that there is a need for *robust project scheduling* (Demeulemeester and Herroelen, 2009).

## 1.2 Problem definition

In the nowadays modern and complex business world where the importance of competition, maintaining reputation and attracting customer satisfaction which have significantly increased, companies try to increase their competition ability to be able to stay in the today's insecure and unpredictable market. To achieve this, companies continually try to use advanced management techniques, high- tech tools and software, and high skilled and experienced human resources.

In the current market, big companies may eliminate small companies from competitive market, while other companies merge together to increase their market share and increase their competitive ability. On the other hand, the speeds of market changes have increased and magnificently forcing companies to adapt their strategies to these changes. As a result, companies should have high flexibility, and conduct many projects in parallel to an integrated management system, reasonable planning, and expert human resources.

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[2] Critical path reflects activities which cannot delayed, and if they delayed, all project plan will be delayed.

One of the main challenges which companies in multi- project environment confronted, are limited human resources, inefficient planning and high uncertainties and associated risks.

To be more specific, it has been decided to work on a case study. Therefore, a service company in oil and gas industry which works on multi- project is selected as a case company.

Due to lack of adequate information at the beginning phase of a project, planning became a challenge. To make a proper and reliable project plan different variety of information such as human resources availability, clear project scope, and project uncertainties from various disciplines is needed in certain time. Gathering such kind of information is always challenge. To be more specific, engineering human resources managers in the engineering department have challenges to availability of human resources and human resource allocation to projects. As a result, decision making has become difficult for engineering managers and project managers.
Currently, the case company use Primavera P6 ™ as a tool to schedule and control project's time and human resources workload. Since there are some unplanned tasks and support activities which are not entered in Primavera P6 ™ and lack of proper and on time updating human resources assignment and availability, engineering human resources managers have poor control on human resources workload and capacity. As a result, sufficient overview of human resources workload in multi-project is not possible. Therefore, all tasks need to be entered in to Primavera P6 ™ in detailed levels otherwise the result would be unreliable, and engineering human resources managers and project managers are not able to forecast human resources capacity for new projects. This leads to low efficiency in utilization of human resources which are the company's most important assets.
Moreover, Lack of information about human resources workload and capacity, affect project planning and scheduling negatively. Meaning that a project with having less accuracy human resources availability information can lead to insufficient and unrealistic project scheduling and cost estimation, and as a result reduce project effectivity and efficiency.

## 1.3 Goals and objectives

This master thesis has one objective and three sub-objectives:

- **Main objective:** Improve human resources allocation and availability in multi-project environment
    - **Sub-objective1:** Assess project scheduling challenges and human resources allocation in multi-project environment
    - **Sub-objective2:** Advantages and disadvantages of using Primavera P6 ™ as scheduling tool
    - **Sub-objective3:** Understanding of project uncertainty towards project scheduling
    - **Sub-objective4:** Propose necessary improvement solution

## 1.4 Limitations

This project is focused on engineering department in the case company. All researches, analysis and solutions done for engineering human resource availability and efficiency in the engineering department. All required data to analyze current situation came from the mentioned department. The gap analysis also done in this department to recognize the distance between current situation and desired situation about human resource availability and allocation. The project's data selected and reported from Primavera P6 ™ tool. Those projects include ongoing projects which are activated and planned projects which are not started yet and waiting for permission to start. Project can get permission to start when the company receive Purchase Order (P.O), also resources have been assigned to the project activities, all documents and information provided and project manager and team members set kick-off meeting.

## 1.5 Thesis layout

This thesis contains nine chapters:

The first chapter is introduction which is mentioned above and includes background, problem definition, goals and objectives and thesis layout.
The second chapter reviews theories relevant to the topic, such as project management standards, project management methods in multi-project environment, project planning and scheduling, resource definition in projects and the last one is about human resource planning and allocation.
In chapter 3, study done on the status quo about scheduling and human resource planning and allocation in the engineering department in the case company.
In chapter 4, Gap analysis process done which identified the gap between current situation and desired situation.
The fifth chapter 5 explained the solution for improvement, project uncertainties measurement, Long-term, medium-term and short-term human resources allocation plan also feedback.
Chapter 6 is discussion about achievements, challenges faced with and lesson learned.
The project conclusion and future works are presented in chapter 7.
In chapter 8, the references used in this project are listed by means of Endnote X8 citation software with Harvard citation style.
And finally, in the appendices in chapter 9 some reports and procedure available which include: human resource planning and allocation procedure, the tables and charts of demand and capacity for each discipline in engineering department. Also, some examples of multi-project plans, engineering human resources workload distribution in multi-project environment and engineering disciplines workload distribution.

# 2 Theory

## 2.1 Project Management Standards

Big organization like projects management done regarding to defined requirements, processes, methods, tools and common terminology to avoid case by case management which will lead to weak results (Metier OEC, 2009). With this background, some organizations developed standards for project management. In table 1 the most important standards for project management are listed but not limited to it (Metier OEC, 2009):

| Organization | Standard | Abbreviation |
|---|---|---|
| Project Management Institute (PMI), USA | A Guide to the Project Management Body of Knowledge | PMBOK® Guide |
| Axelos Limited, UK | Management of successful projects with PRINCE2® | PRINCE2® |
| International Project Management Association (IPMA), Switzerland | International Competence Baseline | ICB |
| Association for Project Managers (APM), UK | APM Body of Knowledge | APM BoK |

*Table 1. Standards for Project Management (Metier OEC, 2009, P.4)*

Above mentioned standards have many things in common, but each has different focus and different goals. Terminology differs some, but project management with different certification of project management will have no difficulties to understand and communicate with each other (Metier OEC, 2009).

**Management of successful projects with PRINCE2®**

The figure 1 shows the core of the PRINCE2 method:

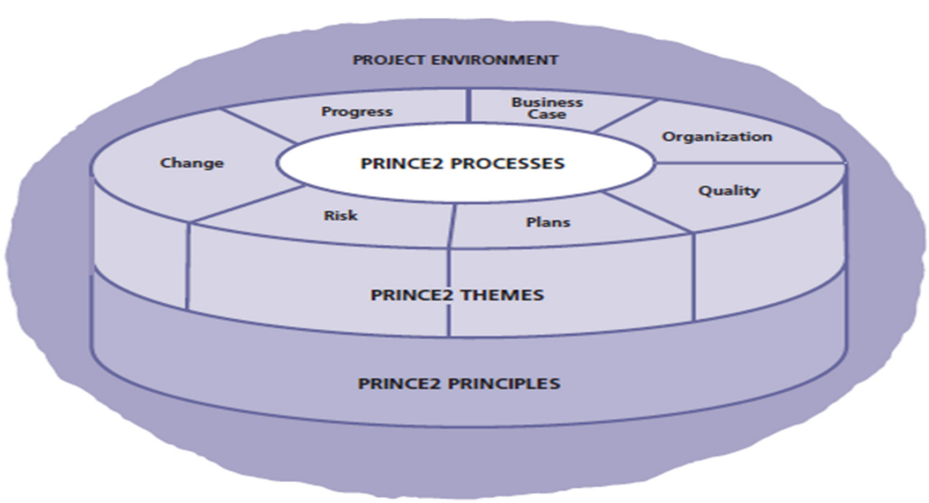



*Figure 1. The structure of PRINCE2 (Metier OEC, 2009, P.7)*

The figure shows the core of the PRINCE2 method: delivering of projects using PRINCE2 themes and processes based on PRINCE2 principles which are tailored to the project and project environment.

**PMBOK® Guide**

The figure 2 illustrates the core of the PMBOK® Guide:


*Figure 2. Overview of Project Management Knowledge Areas and Project Management Processes (Metier OEC, 2009, P.8)*

These are the ten areas of knowledge and associated processes. Each process is linked to one of the main processes to create the dynamics required to perform efficient project management.

**ICB**

ICB breaks professional project management down to 46 competence elements, including 20 technical and methodical competence elements for project management, 15 elements for behavioral and management skills for project staff and 11 context-based competence elements related to projects, programs and portfolios.

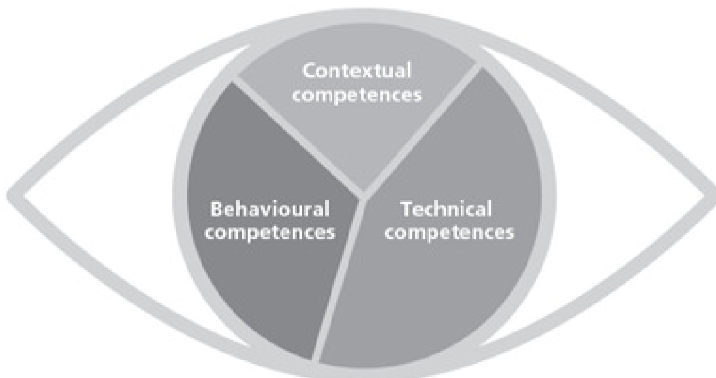



*Figure 3. Competence eye (Metier OEC, 2009, P.8)*

The competence eye as shown in figure 3, reflects the focus of the ICB, showing the integration of all project management elements from project manager's viewpoint when evaluating a concrete situation. The eye also represents clarity and vision. After received information is processed, a competent and responsible project manager will take the necessary measures.

**APM Bok**

APM Bok 5 edition, comprises 52 areas of knowledge (project) for project management through 7 sections shown in table 2, and each topic includes a brief definition and a more detailed explanation.

| Section | Topic |
|---|---|
| Project management in context | Project management |
| Planning and strategy | Project success and benefits management |
| Executing the strategy | Scope management |
| Techniques | Requirements management |
| Business and commercial | Business case |
| Organization and governance | Project life cycles |
| People and the profession | Communication |

*Table 2. APM Bok project management through 7 sections (Metier OEC, 2009, P.9)*

### 2.1.1 Projects definition

**PRINCE 2**

There is a big challenge for nowadays organizations to achieve a balance between their daily operations and at the same time focus on their competing position in market in a successful way (PRINCE2, 2010):

- Keeping current business operations of an organization profitable, customer-oriented, and efficient with high quality services and so on, is called "daily operation" (PRINCE2, 2010).
- To run business operations to be able to survive and keeping its competing position in future, to see organization future and decide how changes in business can introduce in the best way to the organization (PRINCE2, 2010).

When changing speed (technical, business, social, regulations, etc.) increased, organizations punished as they could not manage these changes and follow it, so organization leaders make sure to achieve a balance between their daily operations and changes in the markets they operate (PRINCE2, 2010).

Projects are means organizations used to conduct changes and mange many skills which is needed. This is the main difference of managing daily operations and manage projects (PRINCE2, 2010).

Based on (PRINCE2, 2010, P.3) project definitions, "project is a temporary organization stablished with the object to deliver one or more products which contribute to realize an agreed Business Case[3]."

There are many characteristics which differ projects form daily operations (PRINCE2, 2010, P.3):

- **Change**: projects are means which organizations uses to carry out changes (PRINCE2, 2010, P.3).
- **Temporary**: based on above project definition, projects have temporary nature. When the desired changes take place, the organization return to its daily operation in a new way. All projects should have a defined start and finish (PRINCE2, 2010, P.3).
- **Multidisciplinary**: projects are consisting of a team with members from different skills which worked together in temporary base to conduct a change which will affect others outside the team. Projects often cross normal function in an organization and create sometimes a completely different organization. This often give stresses both inside organization and for example between customers and suppliers. Each theses

[3] As defined in PRINCE2, a business case presents the optimal mixture of information to evaluate if project is (and continually will be) desirable, viable and achievable and therefore it worth.

side have their unique perspective and motivation which linked to the change (PRINCE2, 2010, P.3).

- **Unique**: each project is unique. An organization can have many similar projects and establish a known and proven approach for project work, but each of project will be unique on its way. A different team, different customer, different location. All these factors contribute to fact that projects are unique (PRINCE2, 2010, P.4).
- **Uncertainty**: projects have big uncertainties. This is a characteristic which is already sets for projects. Uncertainty bring risks and opportunities for organizations and it is one the difference of projects and typical daily operations (PRINCE2, 2010, P.4).

**PMBOK**

According to (PMBOK, 2004,P.5) project is a temporary endeavor undertaken to create a unique product, service, or result.

- **Temporary:** Temporary means that each project has a start and finish date. The finish date is the date when deliverables have been delivered and the goals have been achieved and project completed, or it realized that by some reasons, project is stopped or terminated and the project's objectives cannot be achieved. Project's duration are different, some projects take several years and some have short duration but still all those have finish date which make them temporary (PMBOK, 2004, P.5). Generally temporary does not apply to the product, service or result which created by the project. Projects also may often intentionally and unintentionally effect on social, economic and environment (PMBOK, 2004).
- **Unique Products, Services, or Results:** a project can create and generate (PMBOK, 2004, P.5) unique deliverables which are:
  - A product or artifact that is produced, is quantifiable, and can be either end item in itself or a component item
  - A capability to perform a service, such as business functions supporting production or distribution
  - A result, such as outcomes or documents. For example, research project develop knowledge that can be used to determine whether or not a trend is present or a new process will benefit society.

Uniqueness is an important characteristic of project deliverables. Different owner, different design, different location, different contractors, and so on make project unique (PMBOK, 2004).

- **Progressive Elaboration:** Progressive elaboration is also a characteristic of projects. When a project is defined and the scope of work and requirements are broken down in to the details and activities the progress will be measurable (PMBOK, 2004).

- **Projects vs. operational work**

The difference (PMBOK, 2004, P.6) between projects and operations are listed:

- Operations are ongoing and repetitive, while projects are temporary and unique.
- The goals of projects and operations are fundamentally different. The purpose of project is to meet its goal and then terminate. But the goal of an ongoing operation is to sustain the business.
- Projects are different because the project complete when its deliverables have been met, but operations adopt a new set of objectives and keep continue the work.

***Effective Project Management: Traditional, Agile, Extreme***

Project has a specific and strict definition and activities or any work cannot be called project, since not meet the project definition (Wysocki, 2014).

According to (Wysocki, 2014, P.4). A project is a sequence of unique, complex, and connected activities that have one goal or purpose and that must be completed by a specific time, within budget, and according to specification. It is (Wysocki, 2014, P.7) a sequence of finite dependent activities whose successful completion results in delivery of expected business value that validated doing the project.

### 2.1.2 Project management

Project management (PMBOK, 2004, P.8) is the application of knowledge, skills, tools and techniques to project tasks and project deliverables to achieve goals and meet success in certain time and budget. The main challenge of project management is to achieve defined project goals within existing constraints. Project management is the practice of initiating, planning, executing, monitoring, controlling and closing of the work. The project manager is responsible to carry out and implement the project objectives. Managing a project (PMBOK, 2004) includes:

- Identifying requirements such as scope, budget and time
- Establishing project deliverables
- Balancing the competing demands for quality, scope, time and cost
- Adapting the specifications, plans, and approach to different concerns and expectations of the various stakeholders, clients, people and company

Project management knowledge draws on ten areas (PMBOK, 2004):

- **Project Integration Management:** According to the *(PMBOK, 2004, P.9)*, “describes the processes and activities that integrate the various elements of project management, which are identified, defined, combined, unified and coordinated within the Project Management Process Group. It consists of the Develop Project

Charter, Develop Preliminary Project Scope Statement, Develop Project Management Plan, Direct and Manage Project Execution, Monitor and Control Project Work, Integrated Change Control, and Closing Project project management processes."

- **Project Scope Management:** According to the *(PMBOK, 2004, P.9)*, "describes the processes involved in ascertaining that the project includes all the work required, and only the work required, to complete the project successfully. It consists of the Scope Planning, Scope Definition, Create WBS, Scope Verification, and Scope Control project management processes."
- **Project Time Management:** According to the *(PMBOK, 2004, P.10)* "describes the processes concerning the timely completion of the project. It consists of Activity Definition, Activity Sequencing, Activity Resource Estimating, Activity Duration Estimating, Schedule Development, Schedule Control project management processes."
- **Project Cost Management:** According to the *(PMBOK, 2004, P.10)*, "describes the processes involved in planning, estimating, budgeting, and controlling costs so that the project is completed within approved budget. It consists of Cost Estimating, Cost Budgeting, and Cost Control project management processes."
- **Project Quality Management:** According to the *(PMBOK, 2004, P.10)*, "describes the processes involved in assuring that the project will satisfy the objectives for which it was undertaken. It consists of the Quality Planning, Perform Quality Assurance, and perform Quality Control project management processes."
- **Project Procurement Management:** According to the *(PMBOK, 2004, P.10)* definition, "describes the processes that purchase or acquire products, services or results, as well as contract management processes. It consists of Plan Purchases and Acquisition, Plan Contracting, Request Seller Responses, Select Sellers, Contract Administration, and Contract Closure project management processes."
- **Project Human Resource Management:** According to the *(PMBOK, 2004, P.10)* definition, "describes the processes that organize and manage the project team. It consists of the Human Resource Planning, Acquire Project Team, Develop Project Team, and Manage Project Team project management processes."
- **Project Communications Management:** According to the *(PMBOK, 2004, P.10)* definition, "describes the processes concerning the timely and appropriate generation, collection, dissemination, storage and ultimate disposition of project information. It consists of the Communications Planning, Information Distribution, Performance Reporting, and Manage Stakeholders project management processes."
- **Project Risk Management:** According to the *(PMBOK, 2004, P.10)* definition, "describes the processes concerned with conducting risk management on a project. It consists of the Risk Management Planning, Risk Identification, Qualitative Risk Analysis, Risk Response Planning, and Risk Monitoring and Control project management processes."

- **Project Stakeholder Management:** According to the *(PMBOK, 2004, P.235)* definition, "refers to managing communications to satisfy the needs of, and resolve issues with, project stakeholders. Activity managing stakeholders increases the likelihood that the project will not veer off track due to unresolved stakeholder issues, enhances the ability of persons to operate synergistically, and limit disruptions during the project. The project manager is responsible for stakeholder management."
  Project stakeholders are individuals and organizations that are actively involved in the project and influence over the project's goals. Key stakeholders on every project include: Project Manager, Customer/user, Performing organization, Project team members, Project management team, Sponsor, Influencers, and Project Management Office (PMO) *(PMBOK, 2004, P.26)*.

## 2.2 Project Management methods in Multi-project environment

Organizations can have many projects at the same time. Example of Multi-project plans illustrated in figure 5 and more plans are available in Appendix C. According to (Ponsteena and Kusters, 2014, P.166) definition, Multi-Project Management (MPM) is "short- term tactical management of a set of projects in execution that share the same human resources" that illustrated in figure 4.

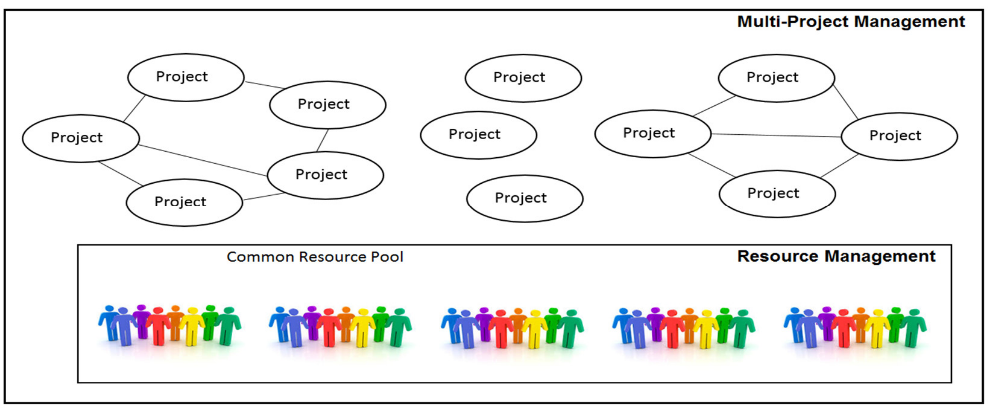
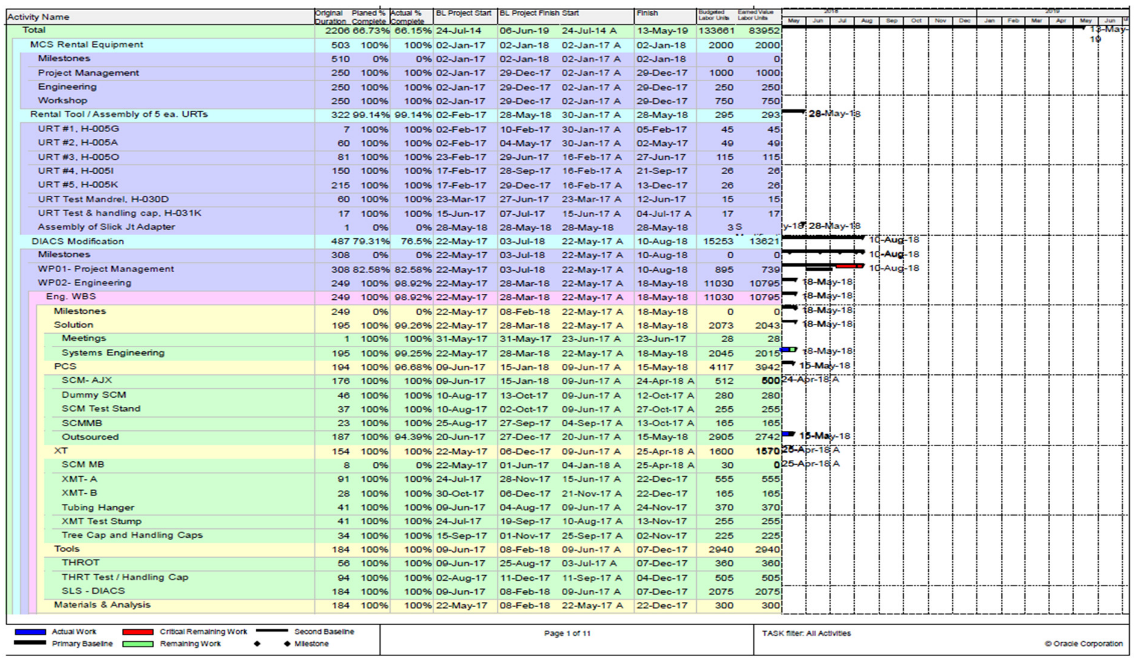



*Figure 4. Multi-Project and Human Resources Management (Ponsteena and Kusters, 2014, P.166)*

There are different MPM approaches in the literature which are shown in table 3. The main important measurable factor which is focused more on multi-project environment is how to plan and organize human resources allocation (Ponsteena and Kusters, 2014).
In this part, we will go through those methods which are more relevant, and proper to our case study.

| Multi-project management approach | Characteristics |
|---|---|
| Heuristic Operational Research | Optimization algorithms |
| Buffer management approach like critical chain | Decentralized decision taking |
| Resource sharing policies with dedicated & core teams and shared resource pools | Dealing with conflicts among PM, RM and portfolio management |

*Table 3. Multi-Project Management approaches* (Ponsteena and Kusters, 2014,P.167)



| Activity Name | Original Duration | Planed % Complete | Actual % Complete | BL Project Start | BL Project Finish | Start | Finish | Budgeted Labor Units | Earned Value Labor Units |
|---|---|---|---|---|---|---|---|---|---|
| Total | 2206 | 66.73% | 66.15% | 24-Jul-14 | 06-Jun-19 | 24-Jul-14 A | 13-May-19 | 133661 | 83952 |
| MCS Rental Equipment | 503 | 100% | 100% | 02-Jan-17 | 02-Jan-18 | 02-Jan-17 A | 02-Jan-18 | 2000 | 2000 |
| Milestones | 510 | 0% | 0% | 02-Jan-17 | 02-Jan-18 | 02-Jan-17 A | 02-Jan-18 | 0 | 0 |
| Project Management | 250 | 100% | 100% | 02-Jan-17 | 29-Dec-17 | 02-Jan-17 A | 29-Dec-17 | 1000 | 1000 |
| Engineering | 250 | 100% | 100% | 02-Jan-17 | 29-Dec-17 | 02-Jan-17 A | 29-Dec-17 | 250 | 250 |
| Workshop | 250 | 100% | 100% | 02-Jan-17 | 29-Dec-17 | 02-Jan-17 A | 29-Dec-17 | 750 | 750 |
| Rental Tool / Assembly of 5 ea. URTs | 322 | 99.14% | 99.14% | 02-Feb-17 | 28-May-18 | 30-Jan-17 A | 28-May-18 | 295 | 293 |
| URT #1, H-005G | 7 | 100% | 100% | 02-Feb-17 | 10-Feb-17 | 30-Jan-17 A | 05-Feb-17 | 45 | 45 |
| URT #2, H-005A | 60 | 100% | 100% | 02-Feb-17 | 04-May-17 | 30-Jan-17 A | 02-May-17 | 49 | 49 |
| URT #3, H-005O | 81 | 100% | 100% | 23-Feb-17 | 29-Jun-17 | 16-Feb-17 A | 27-Jun-17 | 115 | 115 |
| URT #4, H-005I | 150 | 100% | 100% | 17-Feb-17 | 28-Sep-17 | 16-Feb-17 A | 21-Sep-17 | 26 | 26 |
| URT #5, H-005K | 215 | 100% | 100% | 17-Feb-17 | 29-Dec-17 | 16-Feb-17 A | 13-Dec-17 | 26 | 26 |
| URT Test Mandrel, H-030D | 60 | 100% | 100% | 23-Mar-17 | 27-Jun-17 | 23-Mar-17 A | 12-Jun-17 | 15 | 15 |
| URT Test & handling cap, H-031K | 17 | 100% | 100% | 15-Jun-17 | 07-Jul-17 | 15-Jun-17 A | 04-Jul-17 A | 17 | 17 |
| Assembly of Slick Jt Adapter | 1 | 0% | 0% | 28-May-18 | 28-May-18 | 28-May-18 | 28-May-18 | 3 S | |
| DIACS Modification | 487 | 79.31% | 76.5% | 22-May-17 | 03-Jul-18 | 22-May-17 A | 10-Aug-18 | 15253 | 13621 |
| Milestones | 308 | 0% | 0% | 22-May-17 | 03-Jul-18 | 22-May-17 A | 10-Aug-18 | 0 | 0 |
| WP01- Project Management | 308 | 82.58% | 82.58% | 22-May-17 | 03-Jul-18 | 22-May-17 A | 10-Aug-18 | 895 | 739 |
| WP02- Engineering | 249 | 100% | 98.92% | 22-May-17 | 28-Mar-18 | 22-May-17 A | 18-May-18 | 11030 | 10795 |
| Eng. WBS | 249 | 100% | 98.92% | 22-May-17 | 28-Mar-18 | 22-May-17 A | 18-May-18 | 11030 | 10795 |
| Milestones | 249 | 0% | 0% | 22-May-17 | 08-Feb-18 | 22-May-17 A | 18-May-18 | 0 | 0 |
| Solution | 195 | 100% | 99.26% | 22-May-17 | 28-Mar-18 | 22-May-17 A | 18-May-18 | 2073 | 2043 |
| Meetings | 1 | 100% | 100% | 31-May-17 | 31-May-17 | 23-Jun-17 A | 23-Jun-17 | 28 | 28 |
| Systems Engineering | 195 | 100% | 99.25% | 22-May-17 | 28-Mar-18 | 22-May-17 A | 18-May-18 | 2045 | 2015 |
| PCS | 194 | 100% | 96.68% | 09-Jun-17 | 15-Jan-18 | 09-Jun-17 A | 15-May-18 | 4117 | 3942 |
| SCM- AJX | 176 | 100% | 100% | 09-Jun-17 | 15-Jan-18 | 09-Jun-17 A | 24-Apr-18 A | 512 | 500 |
| Dummy SCM | 46 | 100% | 100% | 10-Aug-17 | 13-Oct-17 | 09-Jun-17 A | 12-Oct-17 A | 280 | 280 |
| SCM Test Stand | 37 | 100% | 100% | 10-Aug-17 | 02-Oct-17 | 09-Jun-17 A | 27-Oct-17 A | 255 | 255 |
| SCMMB | 23 | 100% | 100% | 25-Aug-17 | 27-Sep-17 | 04-Sep-17 A | 13-Oct-17 A | 165 | 165 |
| Outsourced | 187 | 100% | 94.39% | 20-Jun-17 | 27-Dec-17 | 20-Jun-17 A | 15-May-18 | 2905 | 2742 |
| XT | 154 | 100% | 100% | 22-May-17 | 06-Dec-17 | 09-Jun-17 A | 25-Apr-18 A | 1600 | 1570 |
| SCM MB | 8 | 0% | 0% | 22-May-17 | 01-Jun-17 | 04-Jan-18 A | 25-Apr-18 A | 30 | 0 |
| XMT- A | 91 | 100% | 100% | 24-Jul-17 | 28-Nov-17 | 15-Jun-17 A | 22-Dec-17 | 555 | 555 |
| XMT- B | 28 | 100% | 100% | 30-Oct-17 | 06-Dec-17 | 21-Nov-17 A | 22-Dec-17 | 165 | 165 |
| Tubing Hanger | 41 | 100% | 100% | 09-Jun-17 | 04-Aug-17 | 09-Jun-17 A | 24-Nov-17 | 370 | 370 |
| XMT Test Stump | 41 | 100% | 100% | 24-Jul-17 | 19-Sep-17 | 10-Aug-17 A | 13-Nov-17 | 255 | 255 |
| Tree Cap and Handling Caps | 34 | 100% | 100% | 15-Sep-17 | 01-Nov-17 | 25-Sep-17 A | 02-Nov-17 | 225 | 225 |
| Tools | 184 | 100% | 100% | 09-Jun-17 | 08-Feb-18 | 09-Jun-17 A | 07-Dec-17 | 2940 | 2940 |
| THROT | 56 | 100% | 100% | 09-Jun-17 | 25-Aug-17 | 03-Jul-17 A | 07-Dec-17 | 360 | 360 |
| THRT Test / Handling Cap | 94 | 100% | 100% | 02-Aug-17 | 11-Dec-17 | 11-Sep-17 A | 04-Dec-17 | 505 | 505 |
| SLS - DIACS | 184 | 100% | 100% | 09-Jun-17 | 08-Feb-18 | 09-Jun-17 A | 07-Dec-17 | 2075 | 2075 |
| Materials & Analysis | 184 | 100% | 100% | 22-May-17 | 08-Feb-18 | 22-May-17 A | 22-Dec-17 | 300 | 300 |

Actual Work, Critical Remaining Work, Second Baseline, Primary Baseline, Remaining Work, Milestone

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TASK filter: All Activities

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*Figure 5. Multi-project plans captured from Primavera in the case company*

As it shown in the figure 5 there are three projects with top level Work Break down Structure (WBS) are running at the same period. The %planned complete and %Actual complete present the status of the project and work performance and showing that the project is a head of the plan, behind the plan or on track. Baseline (BL) start, BL finish are dates which were agreed with client before project start. Start and finish date show the actual start and finish date. Deviation between Baseline dates and actual dates show us delays on schedule. Budgeted labor unit is sum of hours allocated to the project and break it down in to the tasks and earned value labor unit is work performance in term of hours and shows that how much hours used to complete the tasks of the project. The goal of budget and earned value in project plan is to monitor and control the hours and cost within an approved budget. In term of cost and time in projects two indicators are defined and called Cost Performance Index (CPI) and Schedule Performance Index (SPI) and project managers are easily able to assess and measure work performance and efficiency in projects and make a corrective or preventive action to minimize delays during project's lifetime if needed.

CPI is calculated by: Earned Value (EV)/ Actual Cost (AC)

- If the CPI is less than one, shows project is over budget, meaning that company earns less than the amount spent.
- If the CPI is greater than one, shows project is under budget, meaning that company earns more than the amount spent.
- If the CPI is equal to one, shows project is on track and company earns as much as spent (Usmani, 2018).

SPI is calculated by: Earned Value (EV)/ Planned Value (PV)

- If the SPI is greater than one, shows project is ahead of schedule, meaning that more work has been completed than the planned work.
- If the SPI is less than one, shows project is behind schedule, meaning that less work has been completed than the planned work.
- If the SPI is equal to one, shows project is on time, meaning that work is being completed at about the same rate which is planned (Usmani, 2018).

### 2.2.1 Heuristic Methods

To solve human resources allocation problem (Ponsteena and Kusters, 2014), two general scheduling approaches are available, which are exact method or using heuristic method. Exact method is limited to simple scheduling problems while heuristic method is used to deal with complex problems. In practice, it is hard for project managers to apply heuristic methods since they need too much effort to comply with the prerequisites of heuristic methods. However, Priority Rule (PR) which is based on heuristic method is simpler to apply in practice as it required less advance network and prerequisites. PR heuristic can be used in human resources allocation decisions. There are different studies about PR heuristic approach challenges. It is found that different project setting such as human resources utilization factor, project complexity, and the human resources loading factor affect the outcome (Ponsteena and Kusters, 2014).

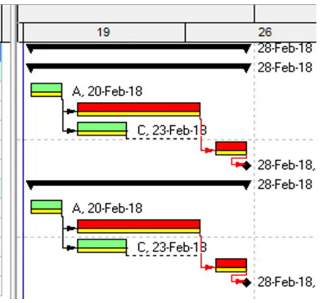
Most heuristic algorithms are based on optimizing activities. In terms of Iron project management triangle which is time, cost (human resources management) and quality (scope), majority of heuristic algorithm is regarded as time focused. In heuristic models, optimization of both time and human resources capacity management are primary objective while scope regarded as a constraint instead of variable in Iron project management triangular (Ponsteena and Kusters, 2014).

Priority rule based on heuristic method is used in most of project management software for human resource leveling. Priority rule based on scheduling have two components, a scheduling scheme and priority rule (Kastor and Sirakoulis, 2009). Some examples of priority rules are minimum slack, minimum latest finish or start time and shortest processing time (Kastor and Sirakoulis, 2009). As *Fondahl* comment, “since human resources got more important role in project and became big challenge for project managers to deal with, the original calculated network data, which are used as priority rules, need to take constrained human resource in to account in scheduling”. As a result “Lu and Li” came up with *Human resource Activity Critical Path Method (RACPM) (*Kastor and Sirakoulis, 2009). The RACPM is a serial path heuristic method based on knowledge-based system of Waugh and Froese, which is able to handle renewable and non-renewable human resources and uses work content as a priority rule (Kastor and Sirakoulis, 2009). *Kim et al.* developed the Human Resource Constrained Critical Path Method (RCPM) to calculate human resource constrained float without the *phantom float*. Phantom float which is exist in project management software packages when applying human resource leveling, is called the difference between theoretical remaining float and the actual remaining total float. An example of Phantom float is illustrated in figure 6 which is based on (Kastor and Sirakoulis, 2009, P.496). (a) Based on Critical Path Method (CPM), both plans (one with human resource constrained and the other without assigned human resource), have the same total float in activity C after scheduling and human resource leveling. While, according to the RCPM it is impossible to work on parallel activities when there are deficit human resources and those activities must be done in sequence. Also, delay on activity B will make delay on whole project, as it shown in figure 6 which is based on (Kastor and Sirakoulis, 2009, P496). (b) Total float are on activities A and B (Kastor and Sirakoulis, 2009).

The advantages of Human Resource Constrained Critical Path Method (RCPM) are:

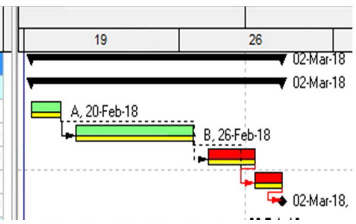
- Enables to provide more realistic schedules by taking in to account limit human resources and their availability.
- Identifies the critical path and calculate float properly.
- Provides stable schedule in a certain required level all over the project life time (Kastor and Sirakoulis, 2009).

| Activity Name | Activity ID | Original Duration | Total Float | Start | Finish | Early Start | Early Finish | Resources | Budgeted Labor Units |
|---|---|---|---|---|---|---|---|---|---|
| Total | | 8 | 0 | 19-Feb-18 | 28-Feb-18 | 19-Feb-18 | 28-Feb-18 | | 69 |
| (New Project) | | 10 | 0 | 19-Feb-18 | 28-Feb-18 | 19-Feb-18 | 28-Feb-18 | | 0 |
| A | A1000 | 2 | 0 | 19-Feb-18 | 20-Feb-18 | 19-Feb-18 | 20-Feb-18 | | 0 |
| B | A1010 | 6 | 0 | 21-Feb-18 | 26-Feb-18 | 21-Feb-18 | 26-Feb-18 | | 0 |
| C | A1020 | 2 | 2 | 21-Feb-18 | 23-Feb-18 | 21-Feb-18 | 23-Feb-18 | | 0 |
| D | A1030 | 2 | 0 | 27-Feb-18 | 28-Feb-18 | 27-Feb-18 | 28-Feb-18 | | 0 |
| E | A1040 | 0 | 0 | | 28-Feb-18 | | 28-Feb-18 | | 0 |
| (New Project) | | 10 | 0 | 19-Feb-18 | 28-Feb-18 | 19-Feb-18 | 28-Feb-18 | | 69 |
| A | A1000 | 2 | 0 | 19-Feb-18 | 20-Feb-18 | 19-Feb-18 | 20-Feb-18 | PEM | 7 |
| B | A1010 | 6 | 0 | 21-Feb-18 | 26-Feb-18 | 21-Feb-18 | 26-Feb-18 | PEM | 35 |
| C | A1020 | 2 | 2 | 21-Feb-18 | 23-Feb-18 | 21-Feb-18 | 23-Feb-18 | PEM | 20 |
| D | A1030 | 2 | 0 | 27-Feb-18 | 28-Feb-18 | 27-Feb-18 | 28-Feb-18 | PEM | 7 |
| E | A1040 | 0 | 0 | | 28-Feb-18 | | 28-Feb-18 | | 0 |




(a) CPM

| Activity Name | Activity ID | Original Duration | Total Float | Start | Finish | Early Start | Early Finish | Resources | Budgeted Labor Units |
|---|---|---|---|---|---|---|---|---|---|
| Total | | 10 | 0 | 19-Feb-18 | 02-Mar-18 | 19-Feb-18 | 02-Mar-18 | | 69 |
| (New Project) | | 12 | 0 | 19-Feb-18 | 02-Mar-18 | 19-Feb-18 | 02-Mar-18 | | 69 |
| A | A1000 | 2 | 2 | 19-Feb-18 | 20-Feb-18 | 19-Feb-18 | 20-Feb-18 | PEM | 7 |
| B | A1010 | 6 | 2 | 21-Feb-18 | 26-Feb-18 | 21-Feb-18 | 26-Feb-18 | PEM | 35 |
| C | A1020 | 2 | 0 | 27-Feb-18 | 01-Mar-18 | 27-Feb-18 | 01-Mar-18 | PEM | 20 |
| D | A1030 | 2 | 0 | 01-Mar-18 | 02-Mar-18 | 01-Mar-18 | 02-Mar-18 | PEM | 7 |
| E | A1040 | 0 | 0 | | 02-Mar-18 | | 02-Mar-18 | | 0 |




(b) Human resource Constrained Schedule

*Figure 6. Phantom float in P6 (Kastor and Sirakoulis, 2009)*

## 2.2.2 Critical chain management

Critical Path Method (CPM) is widely used in project scheduling to ensure that project will be completed on time and on budget. CPM technique Provide information about critical path and free and total float which are required in efficient project planning (Kastor and Sirakoulis, 2009). CPM advantage is giving information about critical and near critical activities which make managers have more control over the project especially in large scale project (Kastor and Sirakoulis, 2009). Moreover, this approach is known to be effective to deal with uncertainty in single project environment, as the time buffer in the schedule protect against uncertainty. In critical chain multi-project environment, projects are linked by constraining human resources which is called drum human resources (Ponsteena and Kusters, 2014). Clear human resources constraint lead to appropriate robust drum planning (Ponsteena and Kusters, 2014). In this approach, the non-constraining human resources have enough capacity to handle a reasonable amount of uncertainty and can protect the scheduling of constraining human resources (drum). However, in many cases there is not a clear drum which make difficult for project managers to control and manage the constraining human resource in multi-project environment (Ponsteena and Kusters, 2014). Moreover, in CPM technique it is assume that human resources are unlimited while in real projects there is human resources are limited (Kastor and Sirakoulis, 2009). Therefore, scheduling without considering human resource deficit would lead to unreliable schedule (Kastor and Sirakoulis, 2009).

The primary goal of critical chain method it to minimize the projects lead-time. In this method, regarding to project management Iron Triangle, time and cost (human resource) are management objectives and are considered as variables, while project scope regarded as a constraint (Ponsteena and Kusters, 2014).

Furthermore, critical chain planning method put more weight on resources which are required to implement plan when they are available. This method is unlike the traditional methods which put weight task order and fixed time plans. A critical chain network aimed to keep the resources evenly distributed. It required that resources should be flexible with respect to start time, and should be able to change fast between task and task chains to keep the whole-time plan (PRINCE2, 2010).

### 2.2.3 Human resources sharing policies

Besides heuristic method, human resource sharing policies dealing with conflicts among project managers, human resource managers and portfolio managers. In multi-project environment decision making is based on human resources sharing policies which are briefly describes below (Ponsteena and Kusters, 2014).

#### 2.2.3.1 *Shared human resources polices*

In this policy, a human resources pool is shared with all projects in the portfolio. The advantage of this policy is increasing efficiency of human resources usage. However, the delay causes by human resources unavailability is a disadvantage, so this makes human resources allocation complex in multi-project environment (Ponsteena and Kusters, 2014).

#### 2.2.3.2 *Human resources dedication policy*

In this approach, dedicated human resources is assigned to the single project in the portfolio. Disadvantage of this policy is that it is not an efficient approach in multi-project setting. Moreover, the project manager just focuses on single project performance characteristic. The advantage of this policy is that human resources allocation problem is solved at the beginning of the projects (Ponsteena and Kusters, 2014).

#### 2.2.3.3 *Relaxed human resources dedication policy*

In this policy the human resources will be available for new projects when they complete the current project. Meaning that they won’t be assigned to another project at the same time. This approach is more common than the full human resources dedication policy (Ponsteena and Kusters, 2014).

#### 2.2.3.4 *Generalized human resources management policy*

This policy is the combination of above mentioned human resources sharing policies, which are: shared human resources policy, dedicated human resources policy, relaxed human resources dedication policy. In this approach, different constraint policy is used for each human resource type as a project uses different type of human resources. A project needs a core team (all-round team member) which are the heart of the project. This core team members are dedicated to the projects. Another group of human resources are the experts who are only needed sometimes in the project. These human resources are typically allocated to multi-project. There are also some routine activities in the projects which are not dependent on specific human resources. These are defined as a service. By defining specific human resources, services can be planned more efficient (Ponsteena and Kusters, 2014).

Adopting the human resources sharing policy is dependent on a company primary objective and there should be an agreement on management level. The primary objective of the *dedicated human resources policy* is to minimized project duration at least for the company's high priority projects. The main objective of *shared human resources policy* is capacity optimization (Ponsteena and Kusters, 2014). The *relaxed human resources dedication policy* is focused more on time optimization than the *generalized human resources management policy*. In all four policies, the scope of a project in Iron project management triangular is considered as a constraint while time and cost (human resources) are management variable (Ponsteena and Kusters, 2014).

In the above mentioned multi-project management methods, critical chain method and heuristic Operational Research (OR) method used automated decision making and human resource sharing policy used human decision approach. Automated decisions mean that an algorithm takes the decision. Automated decisions are calculated based on simplified models of reality. Heuristic OR model improve the decision making by incorporating an increase number of variables. The human decision approach is on the other hand based on idea that an algorithm can never incorporate all the situations that happen in real-life and that human are much more flexible to adjust themselves to unpredictable situations (Ponsteena and Kusters, 2014).

## 2.3 Project planning and scheduling

The main concern of project scheduling is optimal allocation of scarce human resources to activities over time. To schedule a project, precedence and or human resources constrains should be considered. The scheduling which contain activities and planned start and finish time called baseline scheduling. The main usage of baseline scheduling is to allocate human resources to project activities to optimize project performance. Reliable baseline schedule enable project managers to have proper estimation of project life time and duration and take corrective action when required (Demeulemeester and Herroelen, 2009).

*Proactive/Reactive project scheduling* which includes a proactive scheduling procedure for generating robust project scheduling and prepare a reactive scheduling procedures which need to apply when the baseline schedule is disrupt needs to be prepared (Demeulemeester and Herroelen, 2009). *Proactive/Reactive project scheduling* provide a base for robust project scheduling and they have three stages: a) generation of a precedence and human resource feasible baseline schedule, b) protecting project baseline schedules against disruptions that may occur during project schedule, c) prepare and apply a reactive scheduling procedure to repair the baseline schedules when needed during project execution. There is also another approach to deal with uncertainty which called *stochastic project scheduling.* In this approach, a fixed baseline is not generated before project execution and scheduling decisions are dynamically taken by using scheduling policies (Demeulemeester and Herroelen, 2009). More about stochastic scheduling mentioned below. Different project scheduling methods are illustrated in table 4.

### 2.3.1 Project scheduling under uncertainty

Uncertainty is an inevitable aspect of most project, and in many cases project managers often fail to recognize that there are different types of uncertainties and each of them may need especial measures. (Demeulemeester and Herroelen, 2009). These uncertainties are categorized as time uncertainties and human resource uncertainties which describes below:

#### 2.3.1.1 *Time uncertainty*

To consider uncertainty in the duration of project activity Project Evaluation and Review Technique (PERT) has been developed. PERT computes an expected activity duration and variance. It is also minimize the expected total project duration by applying the central limit theory (the sum of a large number of independent random variables which are approximately normally distributed, regardless of the distribution of the individual random variables) (Demeulemeester and Herroelen, 2009). PERT assume that critical path contains a sufficiently large number of activities and those activities are independent (Demeulemeester and Herroelen, 2009). Considering near critical path in the project network, PERT may generate an overly optimistic estimate of the project duration. The interrelationships between the various path in the project network lead to complex interdependencies that are totally ignored. In addition, PERT like as CPM only takes precedence constraints in to account without giving proper treatment of human resource constraints that may affect project planning (Demeulemeester and Herroelen, 2009).

Another approach to deal with uncertainty, called *stochastic project scheduling*. Stochastic project scheduling procedure consider project scheduling as a multi-stage decision process where at each of stage it should be decided which of the precedence and human resource available activities should actually be started (Demeulemeester and Herroelen, 2009). In this approach, the scheduling decisions are made based on past and prior knowledge about the processing time distributions with the goal of minimizing project duration (Demeulemeester and Herroelen, 2009).

The main disadvantage of stochastic project scheduling is the absence of project baseline. Project baseline is considered as a fundamental element of effective project planning, monitoring and control (Demeulemeester and Herroelen, 2009). Without baseline, it is difficult to define project final finish date and measure the performance of the projects in term of cost, time and scope.

#### 2.3.1.2 *Human resources allocation issue*

When there is a constraint in human resources availability, project duration is not just determining by the critical path (the longest path in the network satisfying the precedence constraint). In this situation, relying on critical path calculation may fail to provide an accurate estimate of project duration (Demeulemeester and Herroelen, 2009). Problem of finding a baseline schedule which is consider both precedence and human resource constraint and minimizes the planned project duration is known as the Human Resource Constraint Project Scheduling Problem (RCPSP). In contrast to critical path calculation, optimally solving the RCPSP is hard nut to crack, the problem being *NP*-hard in strong sense (Demeulemeester and Herroelen, 2009). There is an exact algorithm to solve RCPSP. However, in a large scale realistic project with more than 100 activities this algorithm is incapable to solve the problem, and available commercial project planning packages do not yet incorporated to this problem (Demeulemeester and Herroelen, 2009). Despite, the significant availability of efficient and effective hybrid Meta heuristic procedure described in the open literature, commercially available software like as Microsoft Project and Primavera still relay on simple priority rules for solving RCPSP. The potential problem of these software package that used priority rules for solving the RCPSP is large project duration increases which is unneeded and undesirable (Demeulemeester and Herroelen, 2009).

| | | | | | Reactive | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Proactive | | Single mode | | Multi-mode | |
| | Deterministic | Stochastic Time uncertainty | Time uncertainty | Resource uncertainty | Time uncertainty | Resource uncertainty | General disruption types | Time/ resource disruptions |
| Ignores resources | CPM | PERT | | | | | | |
| Considers resources | RCPSP | SRCPSP | Robust resource allocation | No advance information | WET | Exact procedure | Hybrid MIP/CP | Dedicated procedures |
| | | | Quality robustness: critical chain | Advance uncertainty information | Sampling | Heuristics | | |
| | | | Solution robustness: exact and suboptimal procedures | | | | | |

*Table 4. Project scheduling methods (Demeulemeester and Herroelen, 2009, P.6)*

### 2.3.2 Primavera P6™

Primavera P6™ is an oracle base software and it is one of the most powerful tools which is used in projects to plan, schedule, control and monitor single and multi-projects and has high capability to handle large scale and complicated projects. It also provides Critical Path Method (CPM) method which uses the activity durations, sequences between activities, human resources allocation and human resources calendars to calculate a schedule and find the longest duration in the project. It also helps project managers to use Primavera p6™ as a spotlight to track those activities which are in critical path and take corrective and preventive actions when needed to keep project on track.

Furthermore, Primavera P6™ use Earned Value measurement (EVM) technique to measure project cost and time performance against budget and schedule and make possibility to compare how much work has been completed compared to how much work was expected and planned to be completed at given milestones. It is invaluable tool for project managers to keep project management Iron triangular time, costs (human resources) and quality (scope) on track.

Primavera P6™ provide useful information about Project Performance which help top managers in organization to evaluate Key Performance Index (KPI) and projects yield which can be used as input in decision making process.

Some Primavera P6™ features are:

- Balance human resource capacity
- Plan, schedule, and control complex projects
- Allocate human resources and track progress
- Monitor and visualize project performance versus plan
- Conduct what-if analysis and analyze alternative project plans (Oracle 2018)

## 2.4 Resource definition in projects

Resources are widely defined as anything that can be used and add values in to projects, when it used appropriately. Different types of resources can be categorized as follow (Wysocki, 2014):

- Financial: Cash, stocks, insurance policies, and other investments
- Physical: Buildings, machines, computers, materials, trucks, testing facilities, testing equipment, and other equipment
- Human: Managerial, professional, and support staff with known skill and competency profiles
- Information: Data warehouses and marketing data
- Intangible: Culture, software systems, intellectual property, business processes and practices (Wysocki, 2014).

Financial: Cash, stocks, insurance policies, and other investments

Project Financial Management is a process which involves planning, budgeting, accounting, financial reporting, internal control, auditing, procurement, disbursement and the physical performance of the project in order to managing project resources properly and achieving the project's goals. It is a strategic competency for organizations to make project successful (NC State university, 2011).

Physical: Buildings, machines, computers, materials, trucks, testing facilities, testing equipment, and other equipment

Physicals are tangible tools which are used by project team members in different processes and activities in project management and it is essential to complete the project (Project Management Knowledge, 2018).

Human: Managerial, professional, and support staff with known skill and competency profiles

Human resources as a significant asset of companies in terms of skills and abilities, play key and strategic role in project success.

These resources are finite and as a result effective allocation of them is always challenging for project managers. Resources have the following properties:

- They are available based on its scheduled
- They consumed as it is used
- They will degrade or outdated overtime
- They require maintenance to be effective (Wysocki, 2014)

## 2.5 Human resource planning and allocation

Before allocating human resources to projects, it is important to evaluate number of persons should be available to do the project. In a case which there is a need to buy resources, related costs should be calculated. All specific information should be noted (like as name, experience level, availability percentage, when resources are available). With human resource availability information and activity sequence [4]information, project manager can assign human resources to the activities (PRINCE2, 2010).

Human resources allocation is one of the main important challenge that project managers are facing from planning phase of projects and it continues during project's life time. This challenge will be more complicated when it comes in to multi-project environment. Meanwhile, it is one of the key roles for projects to succeed. Essentially, having a proper overview of availability of human resources, amount of their occupied capacity on different projects, human resources limitation and flexibility of human resources are main concerns to overcome this challenge. In order to prevent delays of project due to either inadequate

[4] Activity sequence shows eventual dependencies between activities.

human resources allocation or lack of human resources and also increasing work efficiency, project manages need to use different powerful tools and techniques (Markou et al., 2017).

Experience indicates that in multi-project environment by increasing the number of projects, the demand for more human resources will be increased. Therefore, the first principal is to prioritize projects and prepare list of prioritized projects. Prioritization process is followed by building the master project schedule, capacity planning and high level human resources assignment (Lari et al., 2010). In this prioritization process, complexity of project is not required (Lari et al., 2010). The projects are prioritized based on their benefits, strategic values and initial costs (Lari et al., 2010). When the list of prioritized projects get done, the second step is to generate initial master project schedule which needs human resources allocation (Lari et al., 2010). The third step is to undertake capacity planning (Lari et al., 2010). In the capacity planning parameters such as level of human resources skills, competency, discipline, seniority and availability percentage are evaluated, updated and recorded in the database in a regular basis. The capacity is categorized based on those parameters. According to Scope of Work (SoW) and project requirements, high level human resources which could have generic names are assigned to the projects to measure the workload over the projects lifetime. The real human resources name will be determined when the project activated and kicked-off (Lari et al., 2010).

According to study (Hendriks et al., 1999) done about optimization of human resources allocation process, there are five highlighted elements which are critical in human resources allocation process. These five elements are:

- Long-term human resources allocation
- Medium-term human resources allocation
- Short-term human resources allocation
- Links
- Feedback

These five elements give an organization flexible day to day planning which is in line with the business plan. The central element among these five elements is medium-term human resources allocation and its main output is tough cut capacity planning which is illustrated the ongoing project for a coming month including a rough human resources allocation in each project (Hendriks et al., 1999). Without such a quarterly rough cut capacity planning project leaders are forced to make decision under daily pressure so they do not have enough time for a rough human resources discussion between projects managers and group leaders (Hendriks et al., 1999). The links between various human resources allocation processes is illustrated in figure 7 (Hendriks et al., 1999).

### 2.5.1 Long-term human resources allocation

For a successful human resources allocation, a long-term plan which correspond to company's business plan is needed. Such a plan specifies required human resources for each discipline at least for the coming year. It can be also linked to yearly budget of groups and departments (Hendriks et al., 1999).

### 2.5.2 Medium-term human resources allocation

Since changes in the project portfolio within a year are very probable there is need for new level of human resources allocation which is called medium-term human resources allocation and the main input for this, is the long-term human resources allocation the output of this process must be in line with short-term human resources allocation. The medium-term human resources allocation can be used as a tool to link the budget in to day to day planning. When the human resources over the projects are assigned roughly it is called "*rough cut capacity planning*" which is an important input for the short-term human resources allocation. The rough cut capacity planning should be an agreement between project managers and human resources managers (Hendriks et al., 1999).

### 2.5.3 Short-term human resources allocation

Short-term human resources allocation uses rough cut capacity planning and decision rules as main input. The output would be day to day planning of individual human resources for upcoming weeks. All deviations in this plan can be monitored by project managers (Hendriks et al., 1999).

### 2.5.4 Links

The long-term, medium-term and short-term human resources allocation process must be connected to provide the organization with the required results for running projects. These links must give required information for making right decisions (Hendriks et al., 1999).

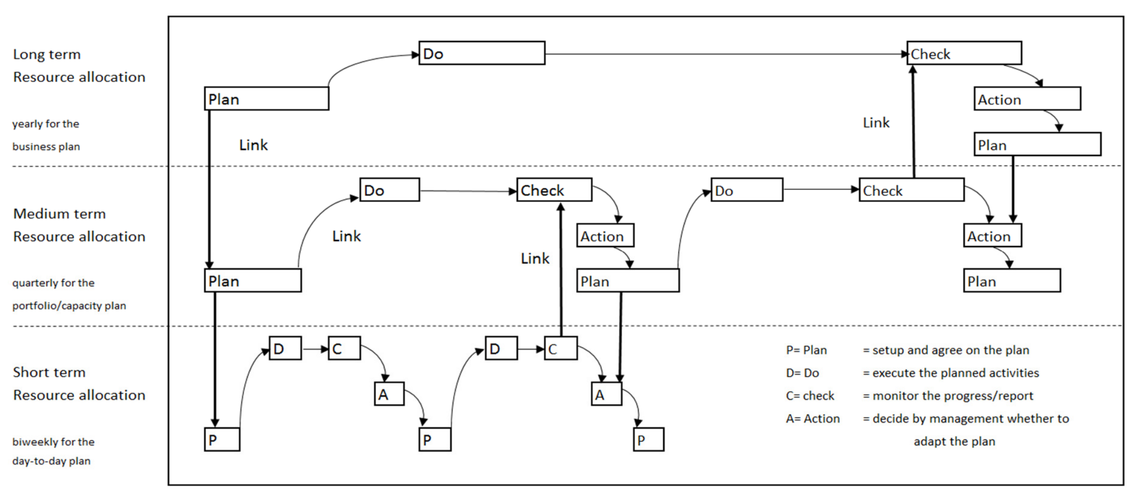



*Figure 7. Links between various human resources allocation processes (Hendriks et al., 1999, P.184)*

### 2.5.5 Feedback

However, the links give input to make right decision, they can be more effective if input evaluated versus real situation. The allocation process can be more effective if they receive feedback (Hendriks et al., 1999).

The number of human resources required to perform a one-year project is called "project scatter factor". To increase efficiency of project the project scatter factor should be as low as possible. So, the project scatter factor 1 is the most desired. To achieve this, project team has to be a small multi-functional team (Hendriks et al., 1999). A high number of project scatter factor means more people needed to fulfill the project and by increasing the number of human resources in the project team, the efficiency of project will get lower. So the number of human resources who are assigned to a project on part time basis should be reduced to increase the project efficiency (Hendriks et al., 1999).

### 2.5.6 Human resources dedication profile

The project efficiency can be increased by changing human resources dedication profile is depicted in figure 8. The project specialist should be transferred to all-round project members, expert and service employees. All- round project members are the core part of project these human resources must have general knowledge of the project must be flexible fitting within the project.  These project members are the first step toward effective and efficient project. Any deviation in the project must be captured by the project member themselves. However, in complex situation which problems cannot be solved by project members they can get help from knowledge of experts. This method also make human resources allocation process easier (Hendriks et al., 1999).

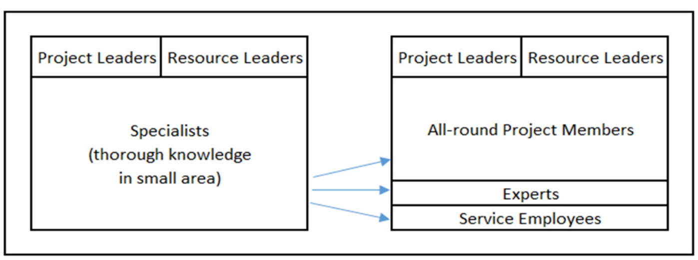



*Figure 8. Human resources dedication profile (Hendriks et al., 1999, P.187)*

Experts must be used in project problem-solving or at project reviews. Experts provides deep knowledge where project members often don't have it to solve complex problems. They give new and extra information to the projects (Hendriks et al., 1999). In the project portfolio, experts will be needed in all the projects in many different times and normally it is difficult to predict when they are needed. Since they are main source of information and play coach role in the project for the team member and team leaders, they cannot be allocated to just one project (Hendriks et al., 1999).  The experts are critical in the human resources allocation process and it is impossible to anticipate their attempt in any single project for a long period of time for example more than couple of weeks. Consequently, we need to forecast the number of expert in long-term human resources allocation and avoid to occupy their capacity on any medium-term human resources allocation and give them more availability to use their free time in collaboration with their team leader (Hendriks et al., 1999).

All projects, consist of many activities which are created by breaking down the scope of work and human resources with different disciplines and roles need to be assigned to each single activity to execute and complete it. But also, there are some activities which are independent of human resources and in a regular basis that can be defined as a service. Typically, assignment of service human resources is not very challenging since it can be provided internally or externally and can be planned independent of people. It is more efficient and organized to plan for services in medium-term human resources allocation process rather than assigning specific human resources (Hendriks et al., 1999).

Human resources allocation based on “human resources dedication profile” will significantly influence the organization performance, therefore project managers must understand the needs for changing specialist in to project members, expert and service employees (Hendriks et al., 1999).

### 2.5.7 **Growth Model**

The five vital elements used in this human resource allocation method can be implemented in almost every company. However, the level and how these elements would be implemented is dependent in situation. In the table 5, a model of how this human resources allocation method can grow is presented (Hendriks et al., 1999).

| Element | Growth Possibility |
|---|---|
| Long-term resource allocation | Assignment of budgets related to business plan |
| Medium-term resource allocation | Set up a project portfolio related to business plan.<br>Assignment of tasks to persons/discipline and decision rules |
| Short-term resource allocation | Resource leaders assign persons according to medium-term allocation |
| Links | Synchronization of the allocation processes, execution of the allocations on the right level, data exchange between the allocation processes |
| Feedback | Feedback of tasks, the projects, and the portfolio in all three allocation processes |

*Table 5. Growth Possibilities of the Five Vital Elements for the Human Resources Allocation Method (Hendriks et al., 1999, P.185)*

### 2.5.8 Gap Analysis

Gap analysis is the technique to identify the areas which need to be improved in any process, system, policies or even the corporate strategies and cultures and keep it into right track. It is either about finding a gap between desired performance and actual performance. To do so, there is a need to generate organized way, process and monitoring system to proactively determining, documenting, monitoring and improving the difference between requirements of the business processes and current capabilities.

In order to create a basic effective Gap Document for Gap Analysis, attempt to identify the Gap between Current Situation and Desire Situation is needed. The Gap Analysis Flow Chart is illustrated in figure 9 (Chhetri, 2018).

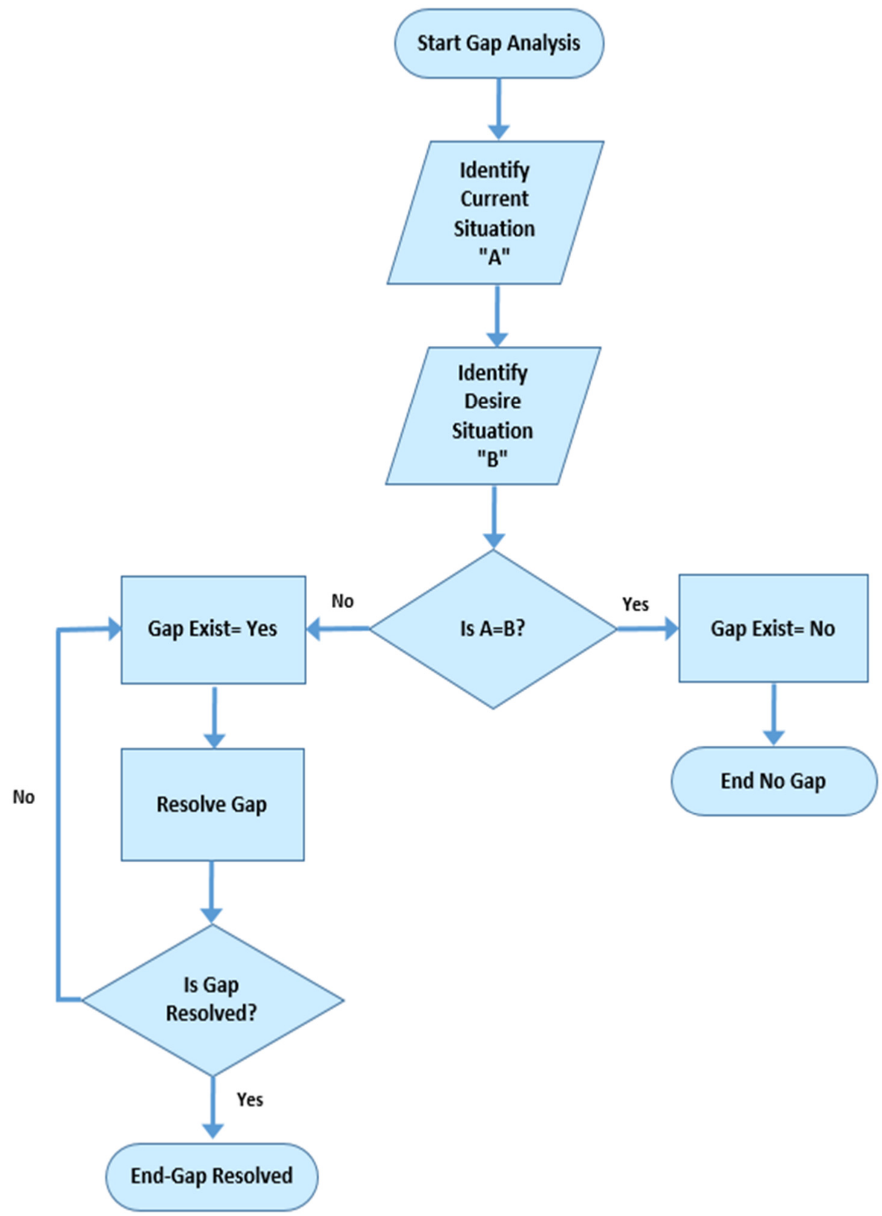



*Figure 9. Gap Analysis Flow Chart (Chhetri, 2018)*

# 3 Status quo

The service company which is selected as a case company is working in oil and gas industry and run many projects in different types of products and parts such as XT, Wellhead, Intervention, Tools, Control system and so on in the same period. This project is focused on engineering department. Poor visibility of human resource availability and inefficient human resource allocation raised as concerns. This chapter is intended to go through the current situation and present how the system is working.

## 3.1 Project Management

Engineering department includes different disciplines such as Hymech, Electrical, Analysis, Material, and Mechanical engineers (Mechanical engineer is also divided in three branches such as XT/Tool, Tic and Mechanical). Many engineers with different level of competency such as Engineers, lead, senior and senior principal Engineers, are working in multi-projects. All used types below from tables 6, 7, 8 and 10. Managers in case of over allocation will decide how to prioritize project for the engineers to work. The level of priorities categorized in table 9 from high priority PL1 to low priority PL5. Detail information about column "Identification" in table 16 are used form those mentioned tables.

| List of Discipline Types |
|---|
| Electrical Engineer |
| Hymech Engineer |
| Mechanical Tic Engineer |
| Mechanical XT/Tool Engineer |
| Mechanical Engineer |
| Material Engineer |
| Analysis Engineer |

*Table 8. Discipline Types*

| Role Titles |
|---|
| All-round Project Member |
| Experts |
| Service Employees |

*Table 6. Role Title*

| Competency Level |
|---|
| Principal |
| Senior Engineer |
| Lead Engineer |
| Engineer |

*Table 7. Competency Level*

| Priority Level |
|---|
| PL1 |
| PL2 |
| PL3 |
| PL4 |
| PL5 |

*Table 9. Priority Level*

| List of Absence Types |
|---|
| Vacation |
| Paternal Leave |
| Sick leave |
| Training |
| Off |

*Table 10. Absence Types*

## 3.2 Project planning and scheduling

After getting project from Inquiry to Order (ITO) team which is responsible to update *deal machine* and according to customer's requirements, department managers prepare scope of work and disciplines which need to be involved in to the projects. Moreover, cost, hours and duration of projects are roughly estimated. If engineering human resources need to be involved in the project, lead engineers create Cost, Time, and Human resource (CTR) sheet to break down the engineering scope in to details, estimate required hours for disciplines and distribute for each one. Project planner is responsible to generate plan in Primavera. Information such as scope of work and detail activities, budget and the minimum required steps to make plan are listed below:

- Break down scope in detail activities as much as it clear, understandable and traceable for plan users and all deliverables must be mentioned in the plan.
- Sequence between activates, this means that how the tasks are going to be done. There are 4 ways to work on activities and it is depend on how the activities should be done and resources availability is also considered. These 4 ways are:
    - Finish to start
    - Start to start
    - Start to finish
    - Finish to finish
- Allocate resources such as human resource, generic name and material to each individual activity if needed.
- Break down hours and budget and allocate to human resources, generic resources and material if required.
- Scheduling the plan after implementing all above items and identify Critical Path.
- Identify final finish date and estimate project life time and duration.
- When resources and budgets allocated to activities, each activity will receive a calculated total cost. The assigned hours and budgets, by default, evenly distributed over duration of the activity. The budgets and hours are aggregated to the WBS level, and the time-phased budget and hours of the WBS Element as it shown in figure 10, will be automatically calculated by Primavera.

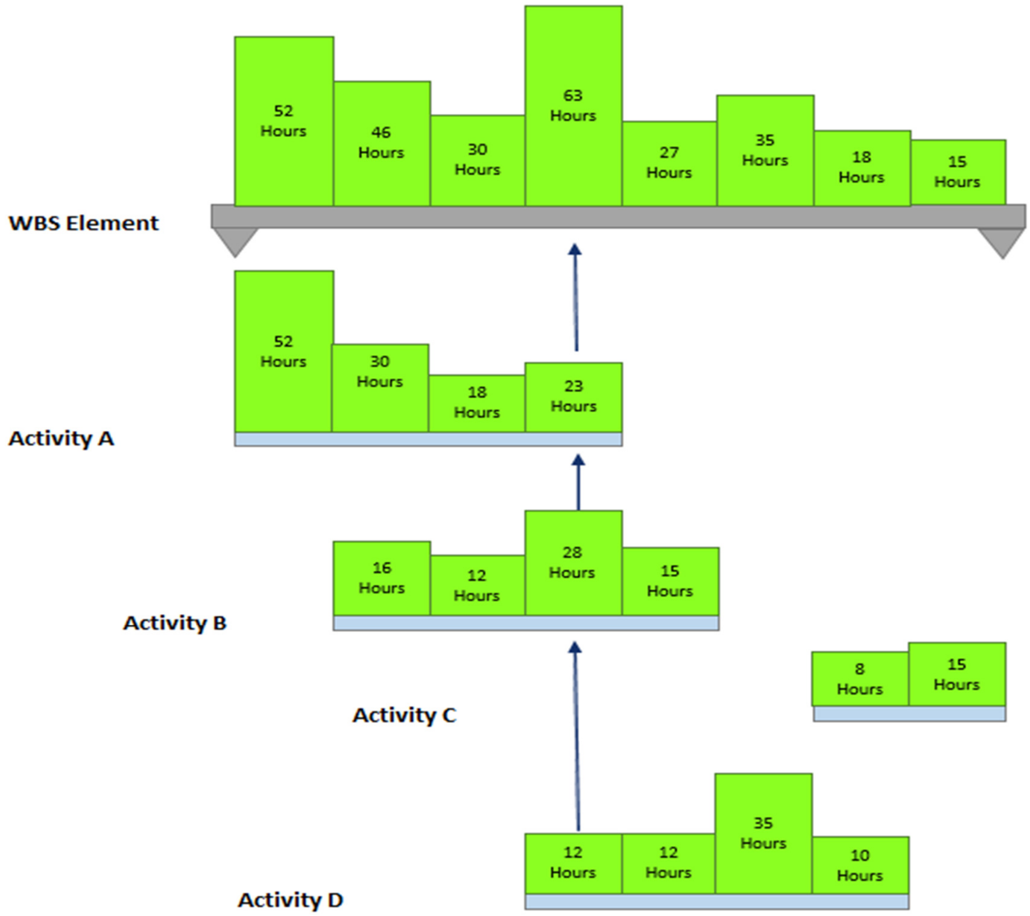
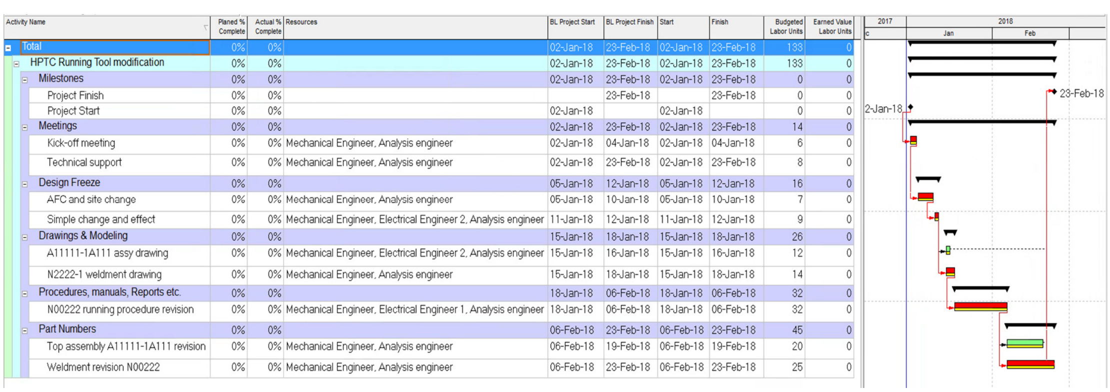



*Figure 10. Distributed hours are aggregated to the WBS level automatically by Primavera*

As per above description, the Gant Chart presented in Figure 11 shown an example of single project plan and shown the critical path which is highlighted in red. By identifying the critical path, project finish date will be estimated and if that date does not satisfy managers, project planner needs to reschedule the plan by do some changes on human resource workload or change the sequences to meet desired finish date.



| Activity Name | Planed % Complete | Actual % Complete | Resources | BL Project Start | BL Project Finish | Start | Finish | Budgeted Labor Units | Earned Value Labor Units |
|---|---|---|---|---|---|---|---|---|---|
| Total | 0% | 0% | | 02-Jan-18 | 23-Feb-18 | 02-Jan-18 | 23-Feb-18 | 133 | 0 |
| HPTC Running Tool modification | 0% | 0% | | 02-Jan-18 | 23-Feb-18 | 02-Jan-18 | 23-Feb-18 | 133 | 0 |
| Milestones | 0% | 0% | | 02-Jan-18 | 23-Feb-18 | 02-Jan-18 | 23-Feb-18 | 0 | 0 |
| Project Finish | 0% | 0% | | | 23-Feb-18 | | 23-Feb-18 | 0 | 0 |
| Project Start | 0% | 0% | | 02-Jan-18 | | 02-Jan-18 | | 0 | 0 |
| Meetings | 0% | 0% | | 02-Jan-18 | 23-Feb-18 | 02-Jan-18 | 23-Feb-18 | 14 | 0 |
| Kick-off meeting | 0% | 0% | Mechanical Engineer, Analysis engineer | 02-Jan-18 | 04-Jan-18 | 02-Jan-18 | 04-Jan-18 | 6 | 0 |
| Technical support | 0% | 0% | Mechanical Engineer, Analysis engineer | 02-Jan-18 | 23-Feb-18 | 02-Jan-18 | 23-Feb-18 | 8 | 0 |
| Design Freeze | 0% | 0% | | 05-Jan-18 | 12-Jan-18 | 05-Jan-18 | 12-Jan-18 | 16 | 0 |
| AFC and site change | 0% | 0% | Mechanical Engineer, Analysis engineer | 05-Jan-18 | 10-Jan-18 | 05-Jan-18 | 10-Jan-18 | 7 | 0 |
| Simple change and effect | 0% | 0% | Mechanical Engineer, Electrical Engineer 2, Analysis engineer | 11-Jan-18 | 12-Jan-18 | 11-Jan-18 | 12-Jan-18 | 9 | 0 |
| Drawings & Modeling | 0% | 0% | | 15-Jan-18 | 18-Jan-18 | 15-Jan-18 | 18-Jan-18 | 26 | 0 |
| A11111-1A111 assy drawing | 0% | 0% | Mechanical Engineer, Electrical Engineer 2, Analysis engineer | 15-Jan-18 | 16-Jan-18 | 15-Jan-18 | 16-Jan-18 | 12 | 0 |
| N2222-1 weldment drawing | 0% | 0% | Mechanical Engineer, Analysis engineer | 15-Jan-18 | 18-Jan-18 | 15-Jan-18 | 18-Jan-18 | 14 | 0 |
| Procedures, manuals, Reports etc. | 0% | 0% | | 18-Jan-18 | 06-Feb-18 | 18-Jan-18 | 06-Feb-18 | 32 | 0 |
| N00222 running procedure revision | 0% | 0% | Mechanical Engineer, Electrical Engineer 1, Analysis engineer | 18-Jan-18 | 06-Feb-18 | 18-Jan-18 | 06-Feb-18 | 32 | 0 |
| Part Numbers | 0% | 0% | | 06-Feb-18 | 23-Feb-18 | 06-Feb-18 | 23-Feb-18 | 45 | 0 |
| Top assembly A11111-1A111 revision | 0% | 0% | Mechanical Engineer, Analysis engineer | 06-Feb-18 | 19-Feb-18 | 06-Feb-18 | 19-Feb-18 | 20 | 0 |
| Weldment revision N00222 | 0% | 0% | Mechanical Engineer, Analysis engineer | 06-Feb-18 | 23-Feb-18 | 06-Feb-18 | 23-Feb-18 | 25 | 0 |



*Figure 11. An example of single project plan*

## 3.3 Engineering human resource allocation

Engineering human resources do not need only to handle and complete their own team projects but also support other teams to meet scope of requirements. Meanwhile, by different reasons such as tasks priorities, project complexity, and human resource availability and so on, they need to be replaced with each other from time to time in projects. Therefore, it is essentially highly important for department managers, human resources managers and project managers to track their workload and capacity. Moreover, managers need to know in which project human resources are involved, how much of their capacity is occupied and when they are not available in the system if they are on vacation, sick leave, paternal leave and so on. Example of engineering resources workload distribution in multi- project environment which is extracted from Primavera in the case company, presented in figure 12 and more examples are available in Appendix D. Example of Engineering disciplines workload distribution which is also captured from Primavera in the case company, shown in Appendix E. Another problem in the case company is lack of routine monthly and quarterly meetings to discuss resource availability and monitor and update short-term, Medium-term and long-term resource allocation plan.

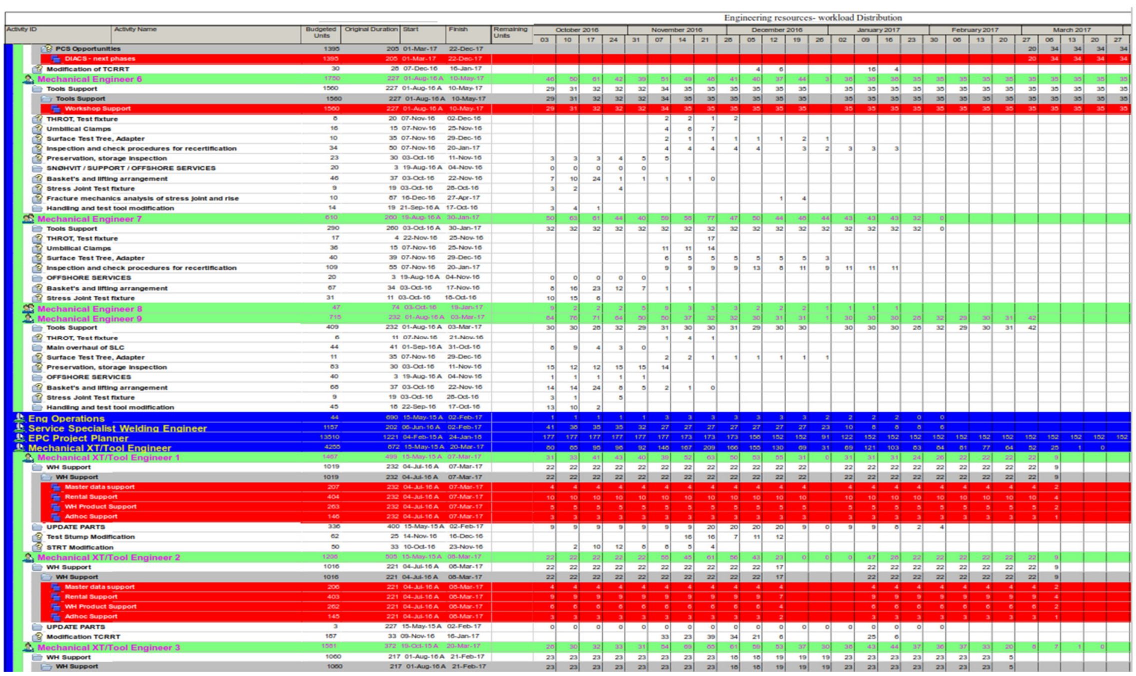



*Figure 12. Example of engineering resources workload distribution in multi- project environment captured from Primavera in the case company*

As it shown in the figure 12 the engineering human resources are allocated to different projects. And remaining hours distributed over the weeks. By having overview of this report project managers, engineering managers can recognize that in which project engineers are involved, how much of their papacies are occupied. But it will more accurate overview and make sense if all information and all engineer’s assignments are entered in Primavera and system correctly and updated properly.

# 4 Gap Analysis

After reviewing current situation, investigation to identify weaknesses of current situation was required. To do so, Research on internal reports, documents and available procedures done. Lots of information gathered from database. Different separate meeting and face to face interviews with engineering managers and engineers separately held. Finally, weaknesses identified and the results summarized in two items, inefficient human resource allocation and poor visibility of human resource availability. Engineering managers are always struggling with human resource allocation to multi-projects due to lack of sufficient information about human resource availability also improper and inappropriate human resource allocation. Desired situations are defined as good vision and more accurate human resource availability and efficient allocation as it shown in Gap analysis diagram in figure 13.

To be more specific, the company gaps in term of human resource availability and allocation are as follow:

- Lack of short-term human resource plan
- Lack of systematic medium-term human resource plan
- Lack of practical long-term human resource plan
- Lack of human resources dedication profile
- Lack of systematic human resources allocation processes
- Lack of project uncertainties identification

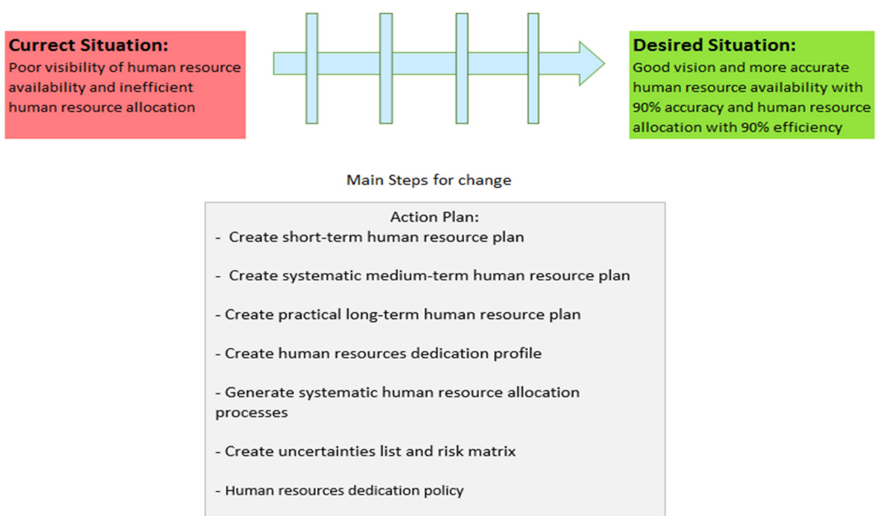



*Figure 13. Gap analysis diagram*

| Current Situation | Desire Situation | Gap |
|---|---|---|
| 1- Poor visibility of human resource availability | Good vision and more accurate human resource availability with 90% accuracy | 90% accuracy of human resource availability |
| 2- Inefficient Human resource allocation to projects properly in multi-project environment | Human resource allocation to projects properly in multi-project environment with 90% efficiency | 90% human resource efficiency |

*Table 11. Gap Analysis table*

The steps below which are also mentioned in the table 11, need to be done for gap analysis.

1. Identify the Current Situation in the first column and list all the current situation functionalities or processes or anything that needs to be performed gap analysis on. In this project, two important weaknesses have been defined which are Poor visibility of human resource availability and Inefficient Human resource allocation to projects properly in multi-project environment.
2. Identify the Desire Situation in the Second Column and list the desire situation corresponding to Current situation. In this project, two targets have been defined which include good vision and more accurate human resource availability with 90% accuracy and human resource allocation to projects properly in multi-project environment with 90% efficiency.
3. The third column can be called "Gap" and if there is a gap between Current situation and desire situation, should be listed in this column. The identified gaps in this project are 90% accuracy of human resource availability and 90% human resource efficiency need to be reached.
4. The fourth Column which is come in table 12 in chapter 5, is called "Gap Resolution". Since Gaps are found, now need to resolve them. In this column mention the detail how the Gap was resolved. All the information need to be provided as possible.

The identified columns are used here because they are more relevant and help to compare the Current situation and Desire situation. More other columns can be added such as Dependencies, Risk, Priority and so one as required in different situations.

# 5 Solution for improvement

Based on current evaluation status and identification of gaps, this section describes the solutions and explain how to overcome the challenges.

In the engineering department of the case company, the aim is to implement a practical and efficient solution to increase the accuracy of human resources availability and workload. Would also help project managers to have better human resources allocation to unplanned activities, support, ongoing and forecast projects. This is a day to day challenge for them to deal with and try to find a proper solution. To overcome the mentioned challenges and make a possibility for the engineering managers to organize the resources workload and capacity, also allow the engineers to do their jobs more efficiently, gap Analysis includes Gap Resolution shown in table 12, prepared. Based on articles, books studies and use relevant experiences and knowledge of employees, the gap resolutions are found. Gap analysis is one of the most important techniques to improve process. It helps to find what sort of necessary actions are required to be taken to fill up the gaps, overcome the problems and meet the targets and desired situation. In this project the desired situations are defined as reaching to 90% visibility of engineering human resource workload and capacity also reaching to 90% efficiency of human engineering resource allocation.

| Current Situation | Desire Situation | Gap | Gap Resolution |
|---|---|---|---|
| 1- Poor visibility of human resource availability | Good vision and more accurate human resource availability with 90% accuracy | 90% accuracy of human resource availability | - Create short-term human resource plan<br>- Create systematic medium-term human resource plan<br>- Create practical long-term human resource plan |
| 2- Inefficient Human resource allocation to projects properly in multi-project environment | Human resource allocation to projects properly in multi-project environment with 90% efficiency | 90% human resource efficiency | - Create human resources dedication profile<br>- Generate systematic human resource allocation processes<br>- Create uncertainties list and risk matrix<br>- Human resources dedication policy |

*Table 12. Gap Analysis table includes Gap Resolution*

In order to estimate the human resources free capacity and estimate workload for day to day activities and upcoming months, the department managers and project managers need to have an effective human resources allocation process. To achieve this, it is proposed that the case study company implements critical elements of human resources allocation process which is in line with the case company business plan. These elements are long-term, medium-term and short- term human resources allocation plans which are linked together and the feedback of this process needs to be evaluated yearly. These five highlighted elements which are critical in human resources allocation process illustrated in figure 17 which presented as Deming cycle: Plan, Do, Check, Act (PDCA) and it is created based on figure 7 in different type. More detail explained in section 2.5.

The first element in this process is long- term human resources allocation plan.

The case company has many projects in different types of products and parts such as XT, Wellhead, Intervention, Tools, Control system etc... These projects are categorized as complex, strategic, mega and small projects. In addition to these projects, there are also some routine and unplanned activities. Since this company has different variety of projects at the same time, it is suggested that the human resource assignment policy chosen is based on the project type. For example, in complex long- term projects *human resources dedication policy* will be used. In this method, human resources are assigned to a single project at a time. In the complex and long-term project, this approach could be appropriate since the project team needs time to focus on just one project at a time. Also in this method, the human resources allocation problem is solved easily. The disadvantage of this approach is that it could lead to negative feelings among company employees about why some of them are chosen for the projects and others not chosen. Moreover, it takes time that lessons from the completed projects which were learned by allocated human resources to be used in new projects.

On the other hand, for simple and short- term projects *Shared human resources polices* can be applied. Meaning that a human resource can be assigned to several projects at same time. This approach increases efficiency of human resource assignment. However, delays caused by human resource unavailability will affect several projects at the same time. Moreover, in this approach human resources allocation is difficult.

In general, it is suggested that the case study company applies *generalized human resources management policy* for human resources allocation base on project type. Since this approach is the combination of different human resources sharing policy, the company can choose specific sharing policy which fits better for their current project and human resource availability. More detail about this policy is mentioned in 2.2.3.4.

To increase project schedule efficiency and accuracy, as described in section 2.3.1.2, the best scheduling method which considers both precedence and human resource constraints and minimizes the planned project duration is known as the human resource Constraint Project Scheduling (RCPS). However, solving the RCPS problem in real large projects is near impossible. Moreover, there is not any commercial project planning package in the market which use this method. As a result, it is proposed that the case company continues sing Primavera P6™ for project planning, scheduling and control. Primavera P6™ is one of the most powerful available software in multi-project environment which use simple priority rules for solving RCPS problem, also to create Critical Path Method (CPM) to estimate final project finish date.

To consider resource constraints in project scheduling it is recommend generating simple, useful and reliable human resources database as a powerful tool beside Primavera ™ to give managers accurate human resources availability for medium-term and short-term forecast (more details in section 5.2 and 5.3).

## 5.1 Long-term human resources allocation plan

In multi-project environment, human resources allocation is difficult and often creates challenges. In this process, it is important to link to company's business plan to long-term human resources allocation plan. Such a plan provides information about required human resources for each department at least for one year. This plan can also link to each department yearly budget.

Long-term human resources allocation should be considered in the business strategy and planning process. The key of human resource planning success is that day to day, medium-term and long-term human resources allocation link together and consequently to the business strategy. By this the company stakeholders would have better understanding of strategic goals and overall needs for a logical and consistent project selection and prioritization. This will lead to reliable human resources allocation process.

A template for long-term human resource allocation plan is illustrated in table 13.

| Required Engineering Human Resources per Discipline | Role Title | Competency Level | Forecast Budget | Hire Goal | Engineering Manager | Status | Comment |
|---|---|---|---|---|---|---|---|
| Hymech Engineer | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Electrical Engineer | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Mechanical Tic Engineer | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Mechanical XT/Tool Engineer | | | | | | | |
| | | | | | | | |
| Mechanical Engineer | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Analysis Engineer | | | | | | | |
| | | | | | | | |
| Material Engineer | | | | | | | |
| | | | | | | | |

*Table 13. Long-term human resources allocation plan*

In the table 13:

- Role Title includes dedication profile: All-round Project Member, Experts, Service Employees
    - All round project members are Senior Engineers, Lead Engineers and Engineers who should be assigned to the projects. These human resources can be allocated to projects with different sharing policies as mentioned in section 2.2.3. Selecting sharing policies depends on project complexity, priority, duration, strategic value and so on.
    - Experts are principal engineers who must be available for any consulting and use their knowledge, skills and experience if needed especially in critical and complicated activities.
    - Service employees are usually used for generic activities such as document control, cost control, planning, support activities, coordinating to give more availability to the Experts and All-round project members and avoid occupation of their capacity.
- Competency Levels are: Principal, Senior Engineer, Lead Engineer, Engineer Competency level could be defined based on human resources knowledge background, skills and experience background.
- Status: On Track, In Progress, At Risk. The status indicates how the process of human resource allocation is, and when they can involve in to the projects.
- Hire goal: the reasons for hiring new human resource need to be mentioned in the column. As an example, the reasons could be:
    - To avoid or reduce human resource over allocation in any of the role Titles
    - To improve the competency level of disciplines
    - Preparing for any predicted changes
- Engineering manager: This person is responsible for his/her team members. If there is a need to hire a new engineer, he/she should send a request to HR department to take an action. Or if an engineer needs special training to increase the level of expertise also the engineering manager will send request to relevant department to make arrangement if possible.
- Comment: if additional description or information is required, it should be mentioned in this column
- Forecast budget: It comes from business plan which is prepared and estimated by top level management every year and keep updated and changed based on market situation and strategic changes periodically.

## 5.2 Medium-term human resources allocation plan

Medium-term human resources allocation plan provides a possibility for engineering managers and project managers to estimate availability and capacity of human resources more accurately for each quarter. This plan needs to be created every quarter and updated when there is a change in project forecast. Having an overview of forecasted projects for each quarter and human resource availability for the next three months enables managers to allocate human resources more efficiently to the forecasted projects to meet demands. In addition, it gives information about human resources availability for each discipline. This information is gathered in the matrix called "medium-term human resources allocation plan" which is illustrated in table 13.

The forecasted projects are pulled out from project portfolio, called "*deal machine*" in the case company and categorized in three level of probability high, medium and low which are determined based on how much managers are certain to get projects. In the case company, Inquiry to Order (ITO) team is responsible to update *deal machine*. According to customer's requirements, department managers prepare scope of work and disciplines which need to be involved in to the projects. Moreover, cost, hours and duration of projects are roughly estimated. If engineering human resources need to be involved in the project, lead engineers create Cost, Time, and Human resource (CTR) sheet to break down the engineering scope into details, estimate required hours for disciplines and distribute for each one. At the beginning of each quarter, managers are responsible to update demands and disciplines availability. Detail responsibility for preparing and updating of medium-term plan is shown in the flow chart medium-term human resources allocation figure 14 which is based on (Hendriks et al., 1999, P.184) .

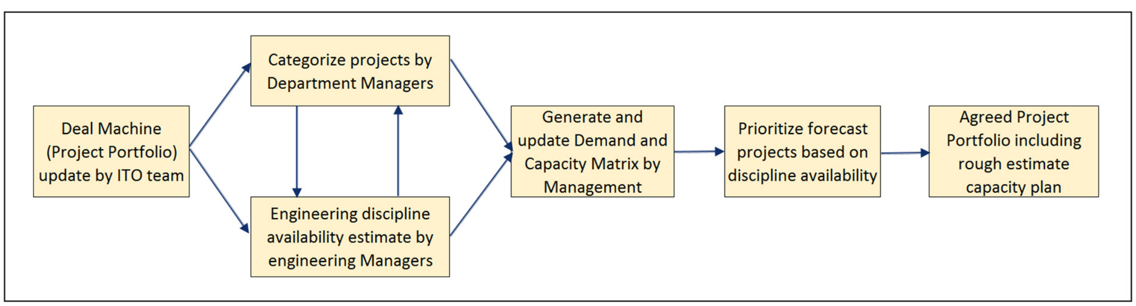



*Figure 14. Flow chart medium-term human resources allocation plan (Hendriks et al., 1999)*

The input for medium-term human resources allocation plan is the long-term human resources allocation plan and its output is used in short-term human resources allocation plan. In case of over allocation in some disciplines and human resources shown in Table 14 and figure 15, the projects with higher probability could be prioritized to balance demand and capacity. The factors that can affect directly on prioritization in case of human resource/discipline over-allocation are financial value, strategic value and project duration.

Quarter demand versus capacity in medium-term allocation plan for each discipline is shown in figure 15 and represents how the allocated hours distributed to disciplines based on requirements. Their capacity, workload and availability are measured independently, also has ability and capacity to measure other index such as discipline occupation and workload based on competency. It also reports workload on projects by different priority level is possible and achievable. Maximum capacity level for each human resource is planned 7.5 hours per day, 37.5 hours per week and 150 hours per month. The capacity level is changeable and needs to be agreed by top managers. Filled-out table can provide a workload versus capacity chart to present the current situation of human resource availability, allowing managers to recognize the probable free gaps between capacity line and workload bars for each individual and discipline per week and month. More Quarter demand versus capacity for each discipline shown in Appendix B.

***Medium-Term Human Resource Allocation Plan for Second Quarter 2018***

| Disciplines | | | Electrical Engineer | Hymech Engineer | Mechanical Tic Engineer | Mechanical XT/Tool Engineer | Mechanical Engineer | Analysis Engineer | Material Engineer | Total Engineering |
|---|---|---|---|---|---|---|---|---|---|---|
| **Ownership** | **Project Name** | **Probability Level** | Estimated Hours | Estimated Hours | Estimated Hours | Estimated Hours | Estimated Hours | Estimated Hours | Estimated Hours | Estimated Hours |
| Tic | Troll concept study | High | 60 | 180 | 165 | 60 | 60 | 105 | 160 | **790** |
| Tic | T/V System Modification | Medium | 0 | 15 | 240 | 195 | 60 | 30 | 80 | **620** |
| Tic | Skarv ROV Panel Project | High | 0 | 0 | 165 | 150 | 450 | 45 | 70 | **880** |
| Tic | SNB Markup Drawing | High | 0 | 0 | 105 | 0 | 0 | 30 | 75 | **210** |
| Tic | SNO THERT | High | 0 | 0 | 150 | 0 | 0 | 40 | 60 | **250** |
| Tic | T/V Check Valves | High | 0 | 0 | 75 | 0 | 0 | 45 | 90 | **210** |
| Tic | SNB PCDM Project | Medium | 0 | 0 | 100 | 0 | 0 | 20 | 80 | **200** |
| Tic | SNB Rental Tools | Medium | 0 | 0 | 30 | 0 | 0 | 30 | 30 | **90** |
| Tic | Troll SSA AOB | Low | 0 | 0 | 135 | 0 | 0 | 30 | 70 | **235** |
| Tic | Tic Adhoc Support | | 0 | 0 | 45 | 0 | 0 | 0 | 0 | **45** |
| XT-Tool | SNB Design Pressure | High | 0 | 45 | 0 | 40 | 150 | 30 | 60 | **325** |
| XT-Tool | Balder Phase 1 | High | 0 | 30 | 0 | 30 | 45 | 0 | 0 | **105** |
| XT-Tool | SNB FD015-K111 | High | 0 | 0 | 0 | 90 | 105 | 60 | 75 | **330** |
| XT-Tool | T/V SLS | Medium | 0 | 0 | 0 | 165 | 240 | 80 | 80 | **565** |
| XT-Tool | T/V PEL Refurbishment | Medium | 0 | 0 | 0 | 30 | 60 | 0 | 0 | **90** |
| XT-Tool | SNO Flowmeter | Low | 0 | 0 | 0 | 150 | 135 | 15 | 75 | **375** |
| XT-Tool | Adhoc Support | | 0 | 0 | 0 | 45 | 45 | 0 | 0 | **90** |
| XT-Tool | P/L XT-Tool | | 0 | 0 | 0 | 180 | 110 | 0 | 0 | **290** |
| Hymech | AkerBP Skarv Project | High | 45 | 300 | 120 | 0 | 0 | 105 | 105 | **675** |
| Hymech | SNB Subsea Project | Medium | 0 | 100 | 0 | 0 | 0 | 0 | 0 | **100** |
| Hymech | P/L Offshore support | | 0 | 360 | 0 | 0 | 0 | 0 | 0 | **360** |
| Hymech | P/L PCS/Choke | | 0 | 90 | 0 | 0 | 0 | 0 | 0 | **90** |
| Hymech | Troll BB015 | Low | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** |
| Electrical | Skarv Control System | Medium | 225 | 50 | 0 | 0 | 0 | 0 | 0 | **275** |
| Electrical | Workshop support | | 120 | 0 | 0 | 0 | 0 | 0 | 0 | **120** |
| Electrical | T/V ROV | High | 330 | 0 | 0 | 105 | 0 | 0 | 0 | **435** |
| Analysis | Tools & XT Analysis Support | | 0 | 0 | 0 | 0 | 0 | 105 | 0 | **105** |
| Analysis | Analysis Support Surface | | 0 | 0 | 0 | 0 | 0 | 300 | 0 | **300** |
| Analysis | Analysis Adhoc Support | | 0 | 0 | 0 | 0 | 0 | 210 | 0 | **210** |
| Material | Tools & XT Material Support | | 0 | 0 | 0 | 0 | 0 | 0 | 150 | **150** |
| Material | Material Support Workshop | | 0 | 0 | 0 | 0 | 0 | 0 | 300 | **300** |
| Material | Material Adhoc Support | | 0 | 0 | 0 | 0 | 0 | 0 | 300 | **300** |
| Total Estimated Hours Per Discipline | | | **780** | **1170** | **1330** | **1240** | **1460** | **1280** | **1860** | **9120** |
| Total Capacity Per Discipline | | | **1312,5** | **1200** | **1275** | **1200** | **2025** | **1500** | **1650** | |
| Demand Capacity Gap | | | **532,5** | **30** | **-55** | **-40** | **565** | **220** | **-210** | **-9120** |

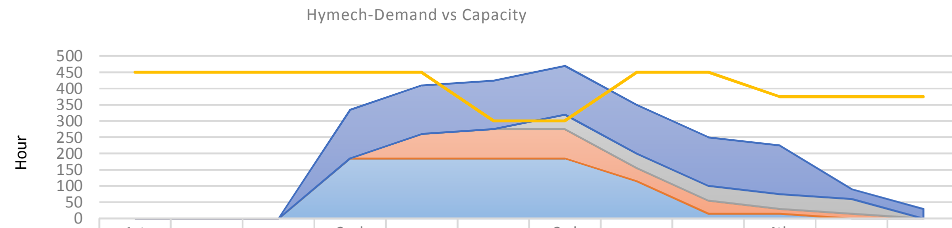
*Table 14. Medium-term human resources allocation plan*

As it shown in table 14, the information below is provided:

- Expected type of demands and ownership of such demands including Tic, XT-Tool, Hymech, Electrical, Material, and Analysis and so on.
- Estimated hours for engineering activities in each project
- Probability level of demand (high, medium or low)
- Estimated hours for each discipline to work on demands
- Total capacity for each discipline
- The probable gap between capacity and estimated workload for each discipline

By having this table, the engineering managers can make informed decisions such as whether they need to hire more engineers in case of over allocation or prioritize the demands based on probability and other factors to avoid over allocation.

## Demand vs. Capacity Chart




| | 1st Quarter | | | 2nd Quarter | | | 3rd Quarter | | | 4th Quarter | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Support Total | 0 | 0 | 0 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 30 | 30 |
| Low Probability | 0 | 0 | 0 | 0 | 0 | 0 | 45 | 45 | 45 | 45 | 45 | 0 |
| Medium Probability | 0 | 0 | 0 | 0 | 75 | 90 | 90 | 40 | 40 | 15 | 15 | 0 |
| High Probability | 0 | 0 | 0 | 185 | 185 | 185 | 185 | 115 | 15 | 15 | 0 | 0 |
| Total Capcaity | 450 | 450 | 450 | 450 | 450 | 300 | 300 | 450 | 450 | 375 | 375 | 375 |

| Quarter | | 1st Quarter | | | 2nd Quarter | | | 3rd Quarter | | | 4th Quarter | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | | jan.18 | feb.18 | mar.18 | apr.18 | mai.18 | jun.18 | jul.18 | aug.18 | sep.18 | okt.18 | nov.18 | des.18 | Hours |
| **Forecast Total** | | | | | | | | | | | | | | |
| **Ownership** | **Project** | **0** | **0** | **0** | **185** | **260** | **275** | **320** | **200** | **100** | **75** | **60** | **0** | **1475** |
| High Probability | | 0 | 0 | 0 | 185 | 185 | 185 | 185 | 115 | 15 | 15 | 0 | 0 | 885 |
| Hymech | AkerBP Skarv Project | | | | 100 | 100 | 100 | 100 | 100 | | | | | 500 |
| Tic | Troll concept study | | | | 60 | 60 | 60 | 60 | | | | | | 240 |
| XT-Tool | SNB Design Pressure | | | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | | | 105 |
| XT-Tool | Balder Phase 1 | | | | 10 | 10 | 10 | 10 | | | | | | 40 |
| | | | | | | | | | | | | | | 0 |
| Medium Probability | | 0 | 0 | 0 | 0 | 75 | 90 | 90 | 40 | 40 | 15 | 15 | 0 | 365 |
| Hymech | SNB Subsea Project | | | | | 50 | 50 | 50 | | | | | | 150 |
| Electrical | Skarv Control System | | | | | 25 | 25 | 25 | 25 | 25 | | | | 125 |
| Tic | T/V System Modification | | | | | | 15 | 15 | 15 | 15 | 15 | 15 | | 90 |
| | | | | | | | | | | | | | | 0 |
| Low Probability | | 0 | 0 | 0 | 0 | 0 | 0 | 45 | 45 | 45 | 45 | 45 | 0 | 225 |
| Hymech | Troll BB015 | | | | | | | 45 | 45 | 45 | 45 | 45 | | 225 |
| | | | | | | | | | | | | | | 0 |
| **Support Total** | | | | | | | | | | | | | | |
| **Ownership** | **Project** | **0** | **0** | **0** | **150** | **150** | **150** | **150** | **150** | **150** | **150** | **30** | **30** | **1110** |
| Hymech | P/L Offshore support | | | | 120 | 120 | 120 | 120 | 120 | 120 | 120 | | | 840 |
| Hymech | P/L PCS/Choke | | | | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 270 |
| | | | | | | | | | | | | | | 0 |
| **Human resources** | | | | | | | | | | | | | | |
| Available Employees | | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 22 |
| Available Contractors | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0,5 | 0,5 | 0,5 | 10,5 |
| Total Demand | | **0** | **0** | **0** | **335** | **410** | **425** | **470** | **350** | **250** | **225** | **90** | **30** | **2585** |
| Total Capacity | | **450** | **450** | **450** | **450** | **450** | **300** | **300** | **450** | **450** | **375** | **375** | **375** | **4875** |
| Demand Capacity Gap | | **450** | **450** | **450** | **115** | **40** | **-125** | **-170** | **100** | **200** | **150** | **285** | **345** | **2290** |

*Figure 15. Quarter Demand vs Capacity in medium term allocation plan*

The chart in figure 15 describes the situation of capacity against the demands for each discipline in each quarter. It shows in which periods the discipline is over loaded and when they have free time and available. The data to generate the chart comes from “Quarter Demand vs Capacity in medium term allocation plan” which is broken down by months and this plan is also come form “Medium-term human resources allocation plan”.

Generally, the capacity line is not a constant line and as it’s shown in figure 15, the level of capacity changes time to time and some factors directly influence on it. To calculate the capacity level, the availability of human resources and normal working day in calendar need to be considered. To calculate the capacity level of each discipline, in addition to those mentioned factors, the number of human resources who are working in the discipline also needs to be taken in to account.

## 5.3 Short-term human resources allocation plan

Short-term plan uses medium- term plan as input, and the output is day to day plan for individuals. Therefore, each human resource knows more than others about all in his/her hands and how busy they are. So, the accuracy of information will be much higher than medium-term and long-term human resource plan. For this purpose, in regular weekly basis each human resource needs to record information of their assigned jobs such as type of job (Ongoing, support or forecast), estimated hours to complete the job, finish date and absence days in generated timesheet. The latest status and information needs to be reviewed by department managers and any comment should be discussed and implemented in the report if required. In this table, priority level of a project and human resource information need to be filled out by department managers. Furthermore, regular short weekly meeting with team member and department managers could be helpful to have adequate data in this timesheet. Each individual needs to fill-out their time sheet form which is illustrated in Table 15 every week.  Table 15 is a basic time sheet and to make it more practical, valuable and useful, it is developed and extended to more columns which is shown in table 16 and called short-term human resource allocation plan. In this chart the bars indicate the human resource workload and the red and yellow lines indicate their capacity. The yellow line shows normal capacity and the red line is sum-up the normal capacity and overtime.

| Human resource Name | Discipline | Date | Day1 | Day2 | Day3 | Day4 | Day5 | Week1 |
|---|---|---|---|---|---|---|---|---|
| Electrical Engineer1 | Electrical Engineer | Total Capacity | | | | | | |
| | | Ongoing | | | | | | |
| | | Support | | | | | | |
| | | Forecast | | | | | | |
| | | Absence | | | | | | |
| | | Overtime | | | | | | |
| | | Free Capacity | | | | | | |

*Table 15. Human resource timesheet*

The timesheet shown in Table 15 is categorized in different sections and contains various information including ongoing, support, forecast (those tasks which are planned but not yet started) and absence in row area, and time which is categorized per day, week and month in column area. More information such as human resource competency level, role title and discipline, also project priority is defined in this table. This timesheet with proper, routine and correct update makes possible to produce valuable reports and excellent input for decision making. Some parameters are taken into account to define the priority level of projects such as project size, complexity, strategical value, price and so on. On the other hand, seniority, background knowledge, expertise and so on, affect competency level of human resources. Each human resource has his/her own table and they need to update it every Friday. This short-term human resource plan makes possible and enable managers to deal with future demands and allocate human resources to them properly.

**Short-term allcation Plan**

| | | | | | | 1. jan. | 2. jan. | 3. jan. | 4. jan. | 5. jan. | 6. jan. | 7. jan. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Resource Name | Identification | | Project Name | Proirity Level | Time | M | T | W | T | F | S | S | Week1 |
| Hymech Engineer1 | Discipline | Hymech Engineer | Ongoing | | | | 5 | 5 | 5 | 5 | | | 20 |
| | | | Project SNB1 | PL2 | | | 2 | 2 | 2 | 2 | | | 8 |
| | | | Project TV1 | PL3 | | | 1 | 1 | 1 | 1 | | | 4 |
| | | | Project SNB2 | PL4 | | | 1 | 1 | 1 | 1 | | | 4 |
| | | | Project Troll1 | PL5 | | | 1 | 1 | 1 | 1 | | | 4 |
| | Role Title | All-round Project Member | Support | | | | 2 | 2 | 2 | 2 | | | 8 |
| | | | P&L S1 | PL2 | | | 1 | 1 | 1 | 1 | | | 4 |
| | | | P&L S2 | PL2 | | | 0,5 | 0,5 | 0,5 | 0,5 | | | 2 |
| | | | SPS S3 | PL3 | | | 0,5 | 0,5 | 0,5 | 0,5 | | | 2 |
| | Competency Level | Lead Engineer | Forecast | | | | 0 | 0 | 0 | 0 | | | 0 |
| | | | Project SNB F1 | PL4 | | | 0 | 0 | 0 | 0 | | | 0 |
| | | | Project SNO F2 | PL4 | | | 0 | 0 | 0 | 0 | | | 0 |
| | | | Project TV2 | PL5 | | | 0 | 0 | 0 | 0 | | | 0 |
| | | | Absence | | | | 0 | 0 | 0 | 0 | | | 0 |
| | | | Vacation | | | | 0 | 0 | 0 | 0 | | | 0 |
| | | | Training | | | | 0 | 0 | 0 | 0 | | | 0 |
| | | | Sick leave | | | | 0 | 0 | 0 | 0 | | | 0 |
| | | | Current Workload | | | | 7 | 7 | 7 | 7 | 0 | 0 | 28 |
| | | | Normal Capacity | | | | 7,5 | 7,5 | 7,5 | 7,5 | | | 30 |
| | | | Overtime | | | | 0 | 0 | 0 | 0 | | | 0 |
| | | | Total Capacity | | | | 7,5 | 7,5 | 7,5 | 7,5 | | | 30 |
| | | | Free Capacity | | | | **0,5** | **0,5** | **0,5** | **0,5** | **0** | **0** | 2 |

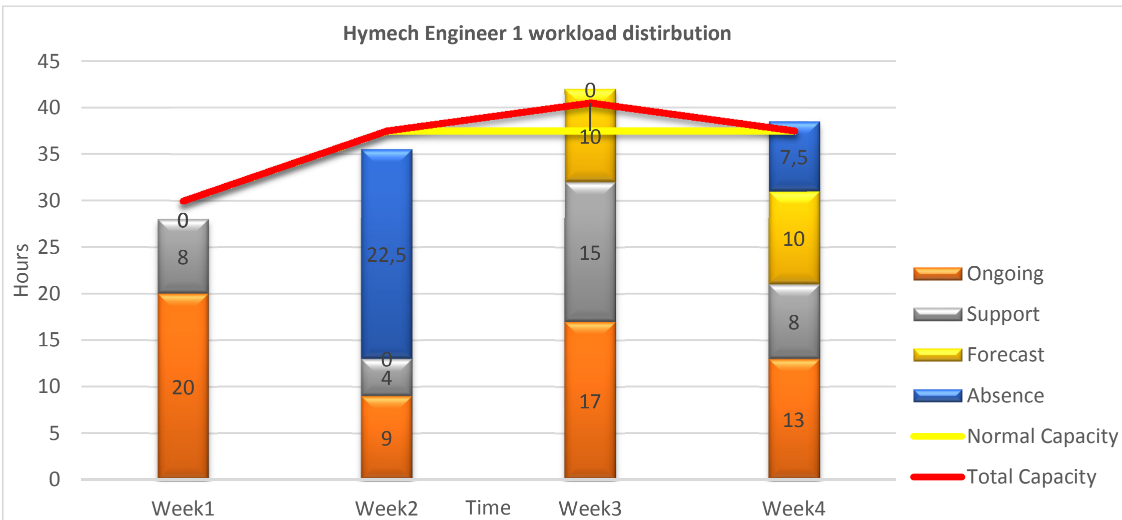
*Table 16. Short-term human resources allocation plan*

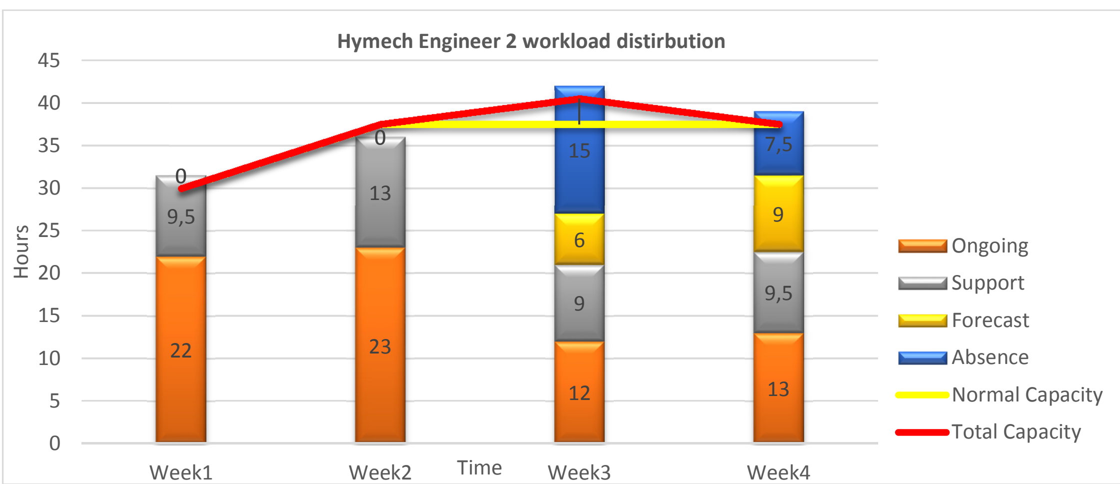
As it’s shown on table 16, each engineer is responsible to fill-out his/her timesheet. It is manadartory for him/her to fill-out The timesheet every week in a regular basis and keep it updated. In this table, the engineer should mention in which project he/she is involved and how many hours allocated to him/her. Those hours must be spread out over task/project life time or at least distributed evenly over the assigned period he/she is asked for.

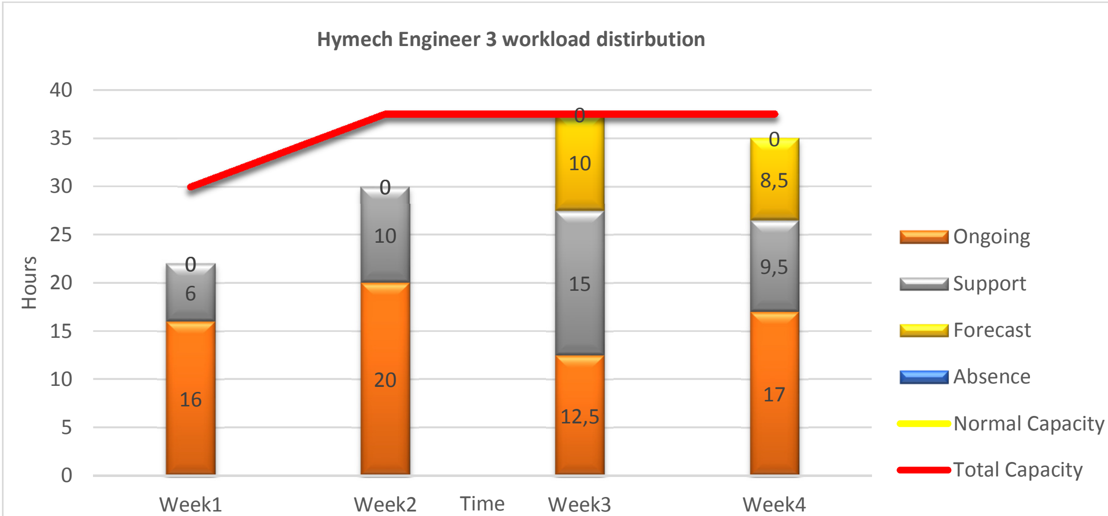
Based on available data from table 16, human resources workload distribution Chart, illustrated in figure 16, is generated and managers can easily can find and recognize the status of human resource capacity and workload.

The columns merged as “identification" should be filled-out by relevant engineering manager. More information about this columns are mentioned in tables 6, 7, 8 and 10. The proirity levels of projects also available in table 9.

**Demand vs Capacity chart**





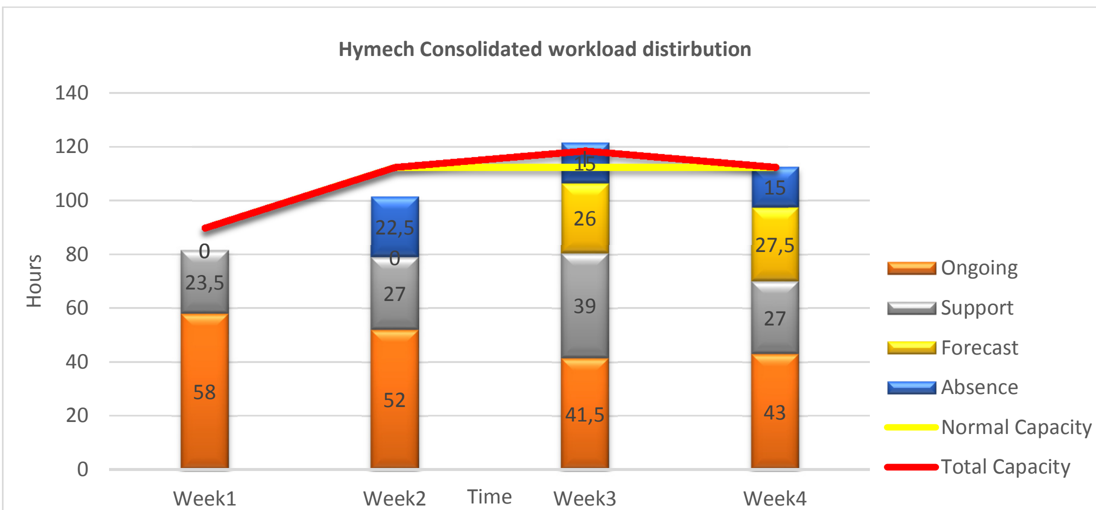




*Figure 16. Human resources and discipline consolidated workload distribution Charts*

As it’s shown in the charts in figure 16:

- The charts are categorized in two different reports:
  - ➢ Human resource workload distribution per week
  - ➢ Discipline workload distribution per week
- The term Ongoing refers to planned projects which are started and activated.
- The term Support refers to unplanned tasks which are not part of project and need engineers to complete them
- The term Forecast refers to projects which are planned but not stared and waiting for permission from project managers to start
- Absence is for vacation, sick leave, Off day and so on
- The bars indicate the monthly workload level of the human resource and/or discipline

- The different colors in the bars show:
    - ➢ Sort of project or task allocated to the human resource/discipline per week
    - ➢ Amount of their time occupied by projects or tasks per week
    - ➢ The lines on top of the bars indicate the level of capacity for each human resource and discipline. They are in two colors yellow indicates normal capacity and the red indicate total capacity.
    - ➢ Normal capacity per week for each human resource is 37,5 hours and for each discipline is calculated: 37,5 times the number of human resource in a discipline
    - ➢ Total capacity per week is the sum-up the normal capacity and overtime.

If the bars exceed from the capacity lines means that the human resource/discipline is over allocated.

If the bars are below the lines means that the human resource/discipline has free capacity and can take more tasks.

Project planning steps are explained in 3.2.

## 5.4 Links

In the long-term human resource allocation plan, analysis team every year analyze the market potential, needs, environment, and competitors and other relevant information and send the feedback with the results to top management. Based on the outcomes of these analysis, top management can predict the future demand for each product and its parts such as control system, Wellhead, XT, and Tools as well as required engineering human resources for engineering department. According to that information, engineering managers can estimate how many engineers are required for each disciple, aligned with human resource dedication profile. If the demands are more than the current discipline's capacity then the engineering managers send a request to HR department to hire more engineers. The outcome of long-term human resource allocation plan is input for the medium-term human resource allocation plan.

In the medium-term human resource allocation plan, managers include department managers, project managers and engineering managers need to break down the forecast demand into three months periods and set regular meetings every quarter to review them and estimate the probability of receiving orders for next quarter. Then allocate relevant disciplines to those demands and measure their workload and capacity. The current workload also should be taken in to account to make full overview of disciplines capacity and workload. In case of over allocation, managers can prioritize the demands based on probability and strategic decision and assign disciplines to the demands based on higher probability of receiving order or importance of demands. If new unpredicted demands come, then the managers need to add in to the plan and estimate the probability of receiving order and re-measure the workload and capacity for each discipline. The outcome of medium-term human resource allocation plan is input for the short-term human resource allocation plan.

In the short-term allocation plan, engineers are responsible to update their time sheet to provide the visibility of their workload and availability in a good condition. Engineering managers should monitor and control engineer's workload and set a short team meeting every week to review engineer's assignments. If engineers are over-allocated or or don't have enough workload or any other challenges related to projects and assigned tasks need to be discussed in this meeting and project manager is responsible to find a proper solution and solve a problem.

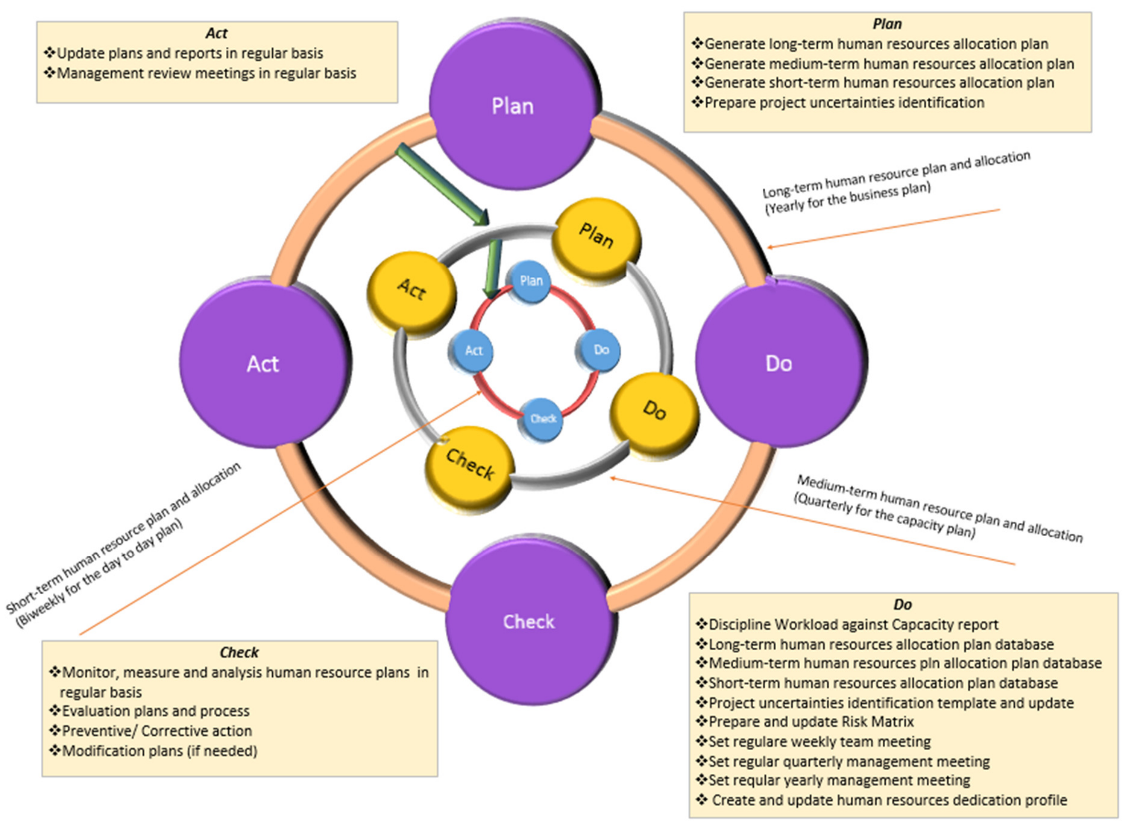



*Figure 17. Links between various human resources allocation processes (Deming cycle)*

As shown in figure 17, is the same as figure 7 but in different type, the big cycle called "long-term human resource plan and allocation" and need to be updated and reported once a year by Department managers, HR department and engineering managers. The outcome of this process will be input for medium-term plan and allocation. The cycle in the middle called "Medium-term human resource plan and allocation" and every quarter need to be updated and reported by department managers and engineering managers. The outcome of this process will be input for short-term plan and allocation. The smallest cycle is called

"Short-term human resource plan and allocation" and the engineers responsible to update it every day and every week and engineering managers are responsible to control, monitor and report it.

Each process has its own steps such as:

- Set the regular meeting with management team and discuss on issues and take proper decision.
- Managers need to prepare uncertainties table and risk matrix and keep them update time to time
- The plan databases for the long-term, medium-term and short-term need to be updated by managers time to time
- Human resources dedication profile need to be generated and updated by the engineering managers time to time
- The plans need to be monitored, measured, evaluated and analyzed time to time
- If there is any failure or risk in the process or reports, management team need to take corrective or preventive action.

## 5.5 Feedback

To make human resource allocation plans more effective, it is necessary to evaluate long-term, medium-term and short-term human resource allocation plans and processes in regular base and improve it when needed. At the end of a year management team should review and evaluate the performance of human resources allocation process to check whether it worked effectively and met the requirements or not. They should analysis the process and the performance of the system to recognize and discover the strengths and weaknesses and find suitable solution to improve them to make system works better and efficient. Human resource planning and allocation Procedure illustrated in Appendix A.

## 5.6 Resource assignment

As mentioned before in, the case company uses Critical Path Method (CPM) for project scheduling and Primavera as project planning tool. However, this method failed to consider human resource constraint (it described more in sections 1.1 and 2.3.1.2). When using CPM method and there is resource constraint, it is recommended that the resources first assigned to the activities which are located on critical path as they have zero slack. Activities with biggest slack[5] have the lowest priority to assign resources. After assigning resources to the activities it is very important to check if critical path has changed due to limited resources availability or lower resources efficiency (PRINCE2, 2010).

[5] Slack is time that an activity can delayed without affecting the whole plan.

## 5.7 Project uncertainties

The second reason for inefficient project planning and scheduling is the fact that at the time a task is scheduled it is assume that human resources availabilities and activity durations are known with certainty. However, in reality uncertainties are natural part of every project and they affect project planning and execution (Demeulemeester and Herroelen, 2009). To be able to manage project uncertainties in project execution phase and increase project planning and scheduling efficiency (robust planning), it is recommended that the case company identify all uncertainties of each project at beginning of project, rank them and adopt preventive measures when needed. These uncertainties can have positive impact (opportunities) on project or negative impacts (risks). To keep the uncertainty list simple and at same time practical, it is recommended to rank each uncertainty possibility of occurrence and its consequences from 1 to 3. Table 17 shows an example of uncertainties list.

| # | Uncertainties | Probability | Consequence |
|---|---|---|---|
| 1 | Lack of enough information on Mechanical XT/Tool Engineers lead to work on activities as finish to start which take too much time to finish design pup-joint | 2 | 1 |
| 2 | There is a risk related to the aggressive schedule, if for any reason, an error occurs Contractor has limited time to correct the error since the offshore operation is set. The consequences of an error i.e. During EFAT may have impact on the schedule. | 3 | 2 |
| 3 | Due to the fact that there are several sourced critical long lead items on this project there is a risk that these items will impact schedule, if for any reasons these parts do not fulfill our quality requirements, meet our need dates and/or are delayed due to bad follow-up. | 3 | 3 |
| 4 | Procurement of parts before Design is completed can lead to purchase of incorrect parts | 1 | 3 |

*Table 17. Uncertainties list*

As per above discussion and the result of table 17, risks are ranked and illustrated in a risk matrix which shown Table 18. It is important that in each project weekly status meeting this risk matrix is also reported and updated if needed.

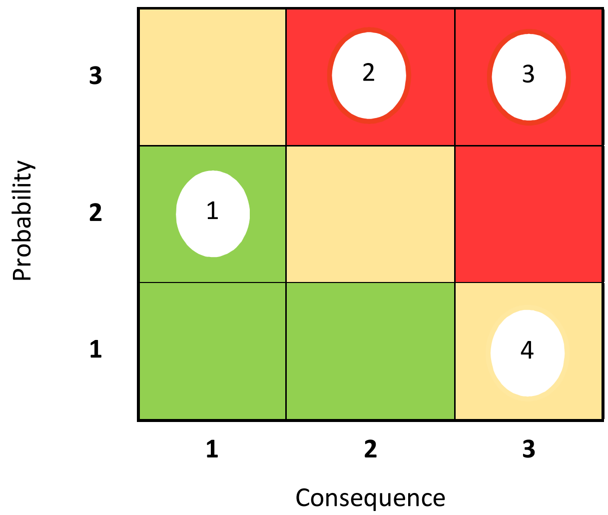



*Table 18. Risk matrix*

### 5.7.1 Project planning uncertainites

To be more specific, it is worth to also conduct uncertainty analysis for planning and scheduling. Each resource and activity, and all other planning information, should be evaluated for potential uncertainty. All identified uncertainties should be registered. Some example of planning uncertainties mentioned below (PRINCE2, 2010):

- Many resources which allocate at the same time to the project, communication weakness can be realized.
- The project plan includes generic resources, and real human resources.
- High number of activities in critical path. A delay in one of them will affect the whole project.
- Plan does not include sufficient point for leadership decision making.
- There is not many slack (floating) in the plan.
- Too many activities running in parallel.
- Several activities executed in short proximity to the critical path dates, increasing the risk of those tasks becoming part of the critical path themselves (PRINCE2, 2010).

# 6 Discussion

The aim of this thesis is to study and investigate the weaknesses on accuracy of human resource availability and the optimal and efficient human resource allocation in multi-project environment in the engineering department in case company. Engineering managers always trying to find proper solution to improve those weaknesses. Since human resources are main asset of companies, utilization of human resources helps and cause companies to have excellent performance, get more achievement and succeed in competition with strong competitors in the world trade.

Lack of proper visibility of human resource capability, capacity and lack of optimal allocation plan in projects especially in multi-project environment lead to failure human resource's motivation and interest. For example, if human resource working under pressure, and load him/her with lots of job more than his/her capacity and vise Vera, if someone has no enough job to do and idle both will gradually lose their motivation. On the other hands, human resources have different capability and competency and if they are not used properly and correctly will also have a negative effect on project performance and project will lead to faultier or long delay. For example, if human resource specialist put his/her force and time to train new employees in the project or even assign to activities which does not need that much expertise to work on, will reduce work efficiency and will also make a delay on project.

The engineering department in the case company has many engineers working in different disciplines. They are involved in many projects and activities in the same period and the engineering managers are facing with challenges and questions such as:

- How can they recognize on which projects their engineers are working?
- How much of engineer's capacity occupied on each project separately and in total?
- How can they allocate engineers to projects optimally?
- How can they have good more accurate vision of engineer's capacity and availability?
- How can they estimate more accurate engineer's availability for future demands?
- How can they estimate future engineering demands?
- How can they prioritize demands when they get increased and how to allocate engineers properly?

To find answers for those questions and find solution for mentioned challenges it was necessary to do gap analysis to identify what needs to be done and the differences between the existing and proposed situation. To do so, I had different several meeting and interview with engineering managers and engineers separately and listed their point of views and problems. Researched and reviewed any internal documents, reports and information which could help me to recognize current state. Also studied lots of books and articles which were relevant to our case and good solutions achieved which are explained and mentioned completely in chapter 5.

Those solutions will have some challenges to implement. The first one will be updating day-to-day timesheet by engineers. Since daily and weekly data entering in the time sheet is time consuming and administrative work, engineers are not willing to spent time to update it and will resist this work which will reduce the level of transparency and accuracy of information. But managers can solve this problem by encouraging engineers and emphasize them to do this job as a kind of assignment. Of course, in long term it will be much easier for engineers and take less time to fill-out information in that sheet. The second problem was lack of procedure for human resource plans includes long-term, medium-term and short- term plans. Therefore, I have prepared this initial procedure which is available in Appendix A and managers are able to do the processes properly.

At the end, I have realized to use proper scarce human resource while using critical path method for project scheduling, it is recommended that the case company assign human resources first to the activities which are on the critical path, and then prioritized activities based on their slack, the minimum slack activities have, and the higher priority activities have for human resource assignment.

# 7 Conclusion

## 7.1 Project conclusions

Nowadays, in the competitive market human resources as a main asset of companies play a key and strategic role in project success. Effective and efficient allocation of scarce human resource is one of the greatest challenges for project and human resource managers to deal with. Systematic human resource planning and allocation helps managers greatly to monitor and control human resource skills, competence, availability and performance. It also enables them to get a more accurate estimation of a project's time schedules, especially in multi-project environment. Furthermore, taking into account the human resource as constrain in scheduling essentially provides reliable project planning and critical path. Since scheduling is used in short-term planning, adequate time schedule by connecting to constraint human resource is highly desired. To achieve this goal, practical templates for long-term, medium-term and short- term human resources allocation plan designed. It is illustrated human resource availability in different time horizon and give managers a useful tool to have overview on their human resources capacity and help them to allocate human resources more efficiently. Moreover, these resource availability plans would lead to more reliable and robust scheduling by giving updated information about human resource availability and constraints.

To increase project schedule reliability and reduce deviations in the plan, it is recommended to identify all projects uncertainties and rank them and find preventive measures for uncertainties with high score.

Furthermore, to consider human resource constraint while using critical path method for project scheduling, it is recommended that the case company assign human resources first to the activities which are on the critical path, and then prioritized activities based on their slack, the minimum slack activities have, and the higher priority activities have for human resource assignment.

In addition, to increase project efficiency it is recommended that the case company use human resource dedication profile categorized in all-round project members, experts and service employees.

## 7.2 Future work

Despite of immense amount of literature and research in scheduling and project management area, still many projects around the world finish with high deviation from their scheduled time and estimated budget. The first reason for ineffective project planning and scheduling, is inadequate attention of project managers to human resource constraints in the project scheduling (Demeulemeester and Herroelen, 2009). In multiple project environment with scarce human resources, project duration should not just have defined by critical path. Since most of companies including the case company using available commercial software which just use simple critical path methodology for project scheduling, they fail to consider human resource constraint appropriately.

On the other hand, human resource Constraint Project Scheduling (RCPS) approach is consider both precedence and human resource constraint and minimizes the planned project duration, but it is not practical in multi- project environment. Since the algorithm to solve RCPS problem can only be used in project with less than 100 activities, it is not practical in real project environment. So, companies with many projects do not have any other way except using available commercial packages.

For future discussion, it is recommended that commercial software cooperated to solve RCPS problems and consequently increase project planning and scheduling efficiency.

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# 9 Appendix

## Appendix A. Human resource planning and allocation Procedure

**Approved By:**

| Document Leader | Resource Manager<br>Project Manager | QMS Leader |
|---|---|---|

***Applicability:***

| *Subsea Product Lines* | |
|---|---|
| ☒ *Projects* | ☒ *Multi-project environment* |

***Document Revision Chart:***

*The following chart lists the revisions made to this document tracked by version. Use this to describe the changes and additions each time this document is re-published. The description should include as many details of the changes as possible.*

| **Rev.** | **Section Modified and Revision Description** | **Date** | **Author(s)** |
|---|---|---|---|
| 0.0 | Human resources planning and allocation method in complex multi-project environment | 15.05.2018 | |
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Table of Contents

## *1 Purpose*

The purpose of this document is to provide a single point of reference for the creation and maintenance of human resource planning and allocation method in complex multi-project environment. Human resources are required for all engineering and project management employees to allocate to projects. This document will also explain the process used by management team and Engineering Operations to ensure a stable operating rhythm.

## *2 Scope & Applicability*

This work instruction is applicable to all oil and gas businesses.

## *3 Terms, Definitions & Acronyms*

Italicized terms have been defined for Terms, Definitions and Acronyms. Acronyms and their definitions have been repeated here for convenience purposes.

| Acronym | Term | Definition |
|---|---|---|
| SoW | | Scope of Work |
| ITO | | Inquiry to Order |
| CTR | | Cost, Time, and Human resource |
| | | |
| | | |
| | | |

## *4 Process Overview / Instruction*

There is key area that need to be created and maintained when creating human resource database. The below topic will guide you through the creation and maintenance of human resource allocation plan.

## *5 Human resource allocation plan*

Human resource database allows managers to gain optimized and efficient human resource allocation in multi project environment. The human resource allocation database is created and maintained by either engineering managers or Engineering Operations depending on the department and access required.

For users to access to the database, a request needs to be sent to the line manager. Long-term human resource allocation plan is set-up by the engineering managers or Engineering Operations Leader. They create and maintain this plan for their departments and assign more access where required. All other requests are to be directed to the engineering managers or Engineering Operations Leader.

This plan is required to review and update when necessary (for example when the data in it is no longer valid) or every six months by engineering managers or Engineering Operations Leader.

Long- term resource allocation template and its required information is mentioned below.

### 5.1 Long-term human resource allocation plan

| Required Engineering Human Resources per Discipline | Role Title | Competency Level | Forecast Budget (Nok) | Hire Goal | Engineering Manager | Status | Comment |
|---|---|---|---|---|---|---|---|
| Hymech Engineer | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Electrical Engineer | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Mechanical Tic Engineer | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Mechanical XT/Tool Engineer | | | | | | | |
| | | | | | | | |
| Mechanical Engineer | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Analysis Engineer | | | | | | | |
| | | | | | | | |
| Material Engineer | | | | | | | |
| | | | | | | | |

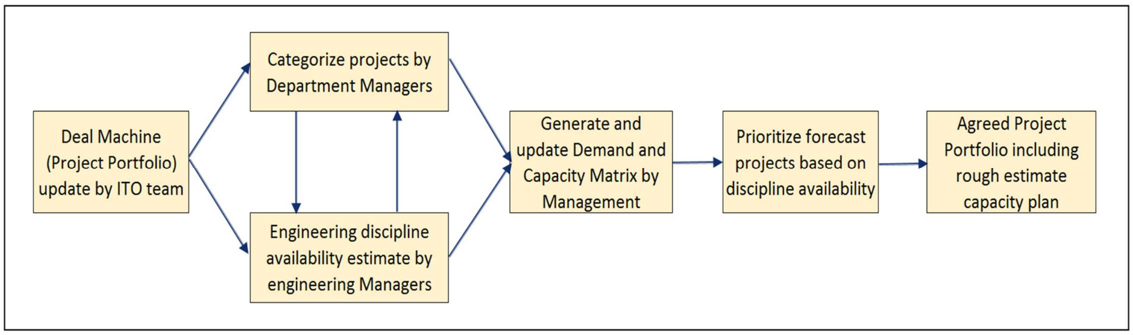
Long-term human resources allocation plan

- Required Engineering Human Resources per Disciplines:
  - Required engineer base on competency level in each discipline
- Role title includes: All-round Project Member, Expert and Service Employees
- Competency level: Principal, Senior Engineer, Lead Engineer, Engineer
- Forecast Budget: comes from business plan
- Hire Goal: the reasons of hiring human resources need to be mentioned in this column
- Engineering Managers: name and signature is needed
- Status: On Track, In Progress, At Risk

### 5.2 Medium-term human resource allocation plan

Medium-term human resources allocation plan provides a possibility for engineering managers and project managers to estimate availability and capacity of human resources more accurately for each quarter. This plan needs to be created every quarter and updated when there is a change in project forecast. Having an overview of forecast project and human resource availability for next quarter, enable managers to allocate human resources more efficiently to the forecast projects to meet demands. In addition, it gives human resources availability information in each discipline. This information is gathered in the matrix called medium-term human resources allocation plan.

The forecast projects are pulled out from project portfolio which is called "*deal machine*" in the case company and categorized in three level of probability high, medium and low which are determined based on how much managers are certain to get projects. Inquiry to Order (ITO) team is responsible to update *deal machine*. In each project, according to customer's requirements and type of product which could be XT, Tool, PCS, Intervention, Wellhead etc. relevant department managers prepare Scope of Work (SoW) and roughly estimate hours which is required. If any engineering activities required for project, relevant department manager send the request to the relevant engineering department to prepare engineering SoW. Then relevant engineering manager ask competence engineer to create cost, hours and duration (CTR) sheet. In this sheet the engineering SoW will be broken down in to detail engineering activities, then disciplines which need to be involved in the project will be defined and required hours estimated for each discipline. At beginning of each quarter, department managers are responsible to update demands and disciplines availability. Detail responsibility for preparing and updating of medium-term human resources allocation plan is shown in the flow chart below:




Flow chart medium-term human resources allocation plan

The input of medium-term human resources allocation plan is from long-term human resources allocation plan and its output used in short-term human resources allocation plan. In case of over allocation in some disciplines and human resources, the projects with higher probability could be prioritized to make balance between demand and capacity. The factors which can affect directly on prioritization in case of human resource/discipline over allocation are financial value, strategic value and project duration. Their capacity, workload and availability is measured independently, also has ability and capability to measure other index such as discipline occupation and workload based on competency. It also reporting workload on projects by different priority level is possible and achievable. Maximum capacity level for each human resource is planned 7.5 hours per day, 37.5 hours per week and 150 hours per month. The capacity level is changeable and need to be agreed by top managers. Medium-term human resources allocation plan shown in the below table:

In the below table:

- **Ownership:** is based on type of product is defined as Intervention, XT, Tool, PCS (Hymech and Electrical), Wellhead, etc.
- **Project name**: list of projects for each department
- **Probability level:** High, Medium, Low
- **Estimated hours:** for each discipline in each project come from CTR
- **Total engineering hours**: for each project is sum-up the estimated hours for each discipline involved in each project
- **Total estimated hours per discipline**: is sum-up the estimated hours in all project
- **Total capacity per discipline:** is calculated: 150 (hours per month) *number of human resources in each discipline *3 months

| Disciplines | | | Electrical Engineer | Hymech Engineer | Mechanical Tic Engineer | Mechanical XT/Tool Engineer | Mechanical Engineer | Analysis Engineer | Material Engineer | Total Engineering |
|---|---|---|---|---|---|---|---|---|---|---|
| **Ownership** | **Project Name** | **Probability Level** | Estimated Hours | Estimated Hours | Estimated Hours | Estimated Hours | Estimated Hours | Estimated Hours | Estimated Hours | Estimated Hours |
| Tic | | High | | | | | | | | |
| Tic | | Medium | | | | | | | | |
| Tic | | High | | | | | | | | |
| Tic | | High | | | | | | | | |
| Tic | | High | | | | | | | | |
| Tic | | High | | | | | | | | |
| Tic | | Medium | | | | | | | | |
| Tic | | Medium | | | | | | | | |
| Tic | | Low | | | | | | | | |
| Tic | | | | | | | | | | |
| XT-Tool | | High | | | | | | | | |
| XT-Tool | | High | | | | | | | | |
| XT-Tool | | High | | | | | | | | |
| XT-Tool | | Medium | | | | | | | | |
| XT-Tool | | Medium | | | | | | | | |
| Total Estimated Hours Per Discipline | | | | | | | | | | |
| Total Capacity Per Discipline | | | | | | | | | | |
| Demand Capacity Gap | | | | | | | | | | |

Medium-term human resources allocation plan

## 5.3 *Short-term human resource allocation plan*

Short-term plan uses medium- term plan as input, and the output is day to day plan for individuals. Short-term human resource plan is mutual relationship between assigned activities and individuals in daily and weekly basis. Therefore, each human resource knows more than others about all in his/her hands and how much busy they are. So, the accuracy of information will be much higher than medium-term and long-term human resource plan. For this purpose, in regular weekly basis each human resource need to record information of assigned job such as type of job (Ongoing, support or forecast), estimated hours to complete the job, finish date and absence days in generated timesheet. The latest status and information needs to be reviewed by department managers and any comment should be discussed and implemented in the report if required. In this table, priority level of a project and human resource information need to be filled out by department managers. Furthermore, regular short weekly meeting with team member and department managers is required to have adequate data in this timesheet. Each individual need to fill-out their time sheet form every week which is illustrated in bellow Table and called short-term human resource.

The timesheet is categorized in different sections and contains various information include: ongoing, support, forecast (those tasks which are assigned but not yet started) and absence in row area, and time which is categorized per day, week and month in column area. More information such as human resource competency level, role title and discipline, also project priority are defined in this table. This timesheet with proper, routine and correct update makes possibility to produce valuable reports and excellent input for decision making. Some parameters are taken in to account to define the priority level of projects like as project size, complexity, strategical value, price and so on. On the other hand, seniority, background knowledge, expertise and so on, affect competency level of human resources. Each human resource has his/her own table and they need to update it every Friday. This short-term human resource plan make possibility and enable managers to deal with future demands and allocate human resources to them properly.

| | | | | | | 1. jan. | 2. jan. | 3. jan. | 4. jan. | 5. jan. | 6. jan. | 7. jan. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Resource Name | Identification | | Project Name | Proirity Level | Time | M | T | W | T | F | S | S | Week1 |
| Hymech Engineer1 | Discipline | Hymech Engineer | | | Ongoing | | 5 | 5 | 5 | 5 | | | 20 |
| | | | Project SNB1 | PL2 | | | 2 | 2 | 2 | 2 | | | 8 |
| | | | Project TV1 | PL3 | | | 1 | 1 | 1 | 1 | | | 4 |
| | | | Project SNB2 | PL4 | | | 1 | 1 | 1 | 1 | | | 4 |
| | | | Project Troll1 | PL5 | | | 1 | 1 | 1 | 1 | | | 4 |
| | Role Title | All-round Project Member | | | Support | | 2 | 2 | 2 | 2 | | | 8 |
| | | | P&L S1 | PL2 | | | 1 | 1 | 1 | 1 | | | 4 |
| | | | P&L S2 | PL2 | | | 0,5 | 0,5 | 0,5 | 0,5 | | | 2 |
| | | | SPS S3 | PL3 | | | 0,5 | 0,5 | 0,5 | 0,5 | | | 2 |
| | Competency Level | Lead Engineer | | | Forecast | | 0 | 0 | 0 | 0 | | | 0 |
| | | | Project SNB F1 | PL4 | | | 0 | 0 | 0 | 0 | | | 0 |
| | | | Project SNO F2 | PL4 | | | 0 | 0 | 0 | 0 | | | 0 |
| | | | Project TV2 | PL5 | | | 0 | 0 | 0 | 0 | | | 0 |
| | | | | | Absence | | 0 | 0 | 0 | 0 | | | 0 |
| | | | | Vacation | | | 0 | 0 | 0 | 0 | | | 0 |
| | | | | Training | | | 0 | 0 | 0 | 0 | | | 0 |
| | | | | Sick leave | | | 0 | 0 | 0 | 0 | | | 0 |
| | | | | | Current Workload | | 7 | 7 | 7 | 7 | 0 | 0 | 28 |
| | | | | | Normal Capacity | | 7,5 | 7,5 | 7,5 | 7,5 | | | 30 |
| | | | | | Overtime | | 0 | 0 | 0 | 0 | | | 0 |
| | | | | | Total Capacity | | 7,5 | 7,5 | 7,5 | 7,5 | | | 30 |
| | | | | | Free Capacity | | **0,5** | **0,5** | **0,5** | **0,5** | **0** | **0** | 2 |

Short-term human resources allocation plan

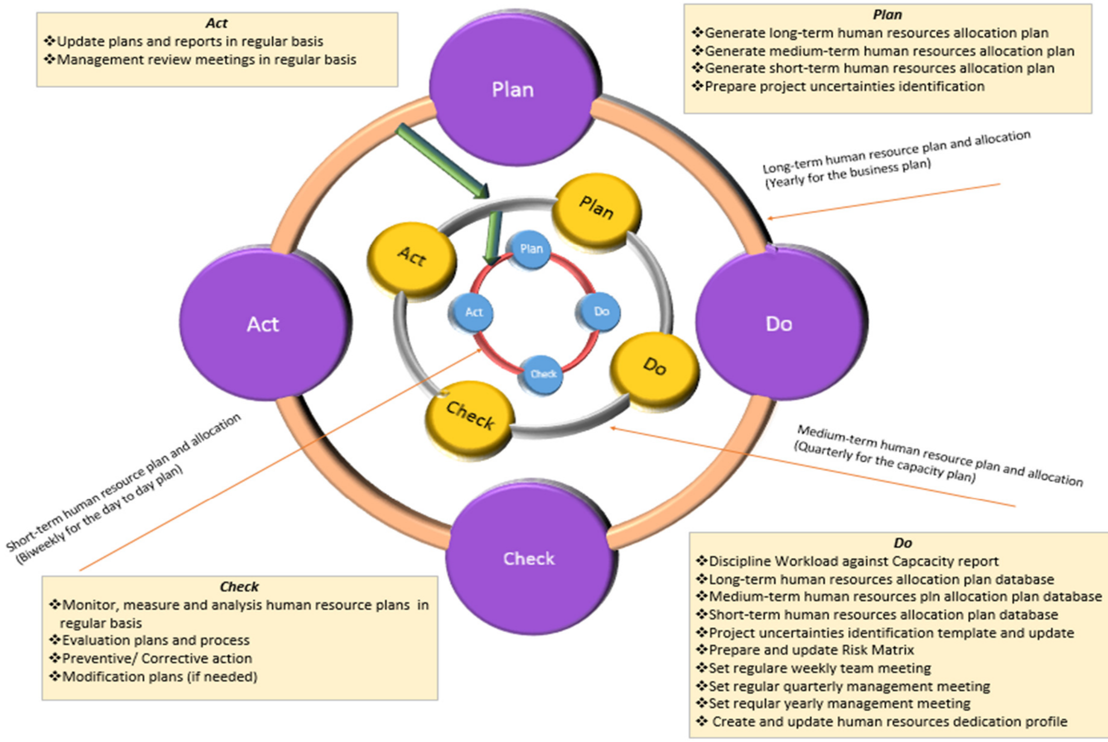
- **Human Resource Name:** Each engineer has his/her timesheet
- **Identification:** Is fulfilled by relevant engineering manager and includes:
    - **Discipline:** Includes Electrical Engineer, Hymech Engineer, Mechanical Tic Engineer, Mechanical XT/Tool Engineer, Mechanical Engineer, Material Engineer,
    - **Role Title:** Includes All-round Project Member, Experts, Service Employees
    - **Competency Level:** Principal, Senior Engineer, Lead Engineer, Engineer
- **Project Name:** List of projects should be written it this column
- **Priority Level:** Is defined from 1 (highest priority) to 5 (lowest priority) and defined based on financial value, strategic value and project duration
- **Time:** Based on calendar and shown date and days of month
- **Ongoing:** All ongoing projects which are assigned to the engineer and remaining hours must be distributed per working days
- **Support:** All unplanned tasks and support which are not included in project must to be shown in this section and remaining hours must be distributed per working days
- **Forecast:** All planned projects which are going to start in the future and assigned to engineer must be listed and allocated hours must be distributed per working days.
- **Absence:** Type of absence such as vacation, Paternal Leave, Sick leave, Training, off must be listed and shown for how long they are unavailable.
- **Current Workload:** Shown each engineer how many hours per day is working on assigned activities and it comes from sum-up the hours from ongoing, support and forecast minus absence
- **Normal Capacity:** Is 7,5 hours per day
- **Overtime:** If engineer allows to work overtime can fill out amount of time used as overtime on relevant project or task in this line
- **Total Capacity:** Is sum-up the normal capacity and overtime
- **Free Capacity:** Minus total capacity and current workload

### *5.4 Links between various human resource allocation processes*

In the long-term human resource allocation plan, every year analysis team, analyze the market potential, needs, environment, and competitors and so on and send the feedback with the results to top management. Based on the outcomes of these analysis, top management can predict the future demand for each product and its parts such as control system, Wellhead, XT, and Tools also required engineering human resources for engineering department. According to those information engineering managers can estimate how many engineers are required for each disciple, aligned with human resource dedication profile. If the demands are more that current discipline's capacity then the engineering managers send a request to HR department to hire more engineers. The outcome of long-term human resource allocation plan is input for the medium-term human resource allocation plan.

In the medium-term human resource allocation plan, managers include department managers, project managers and engineering managers need to break down the forecast demand into three months periods and set regular meetings every quarter to review them and estimate the probability of receiving orders for next quarter. Then allocate relevant disciplines to those demands and measure their workload and capacity. The current workload also should be taken in to account to make full overview of disciplines capacity and workload. In case of over allocation, managers can prioritize the demands based on probability and strategic decision and assign disciplines to the demands based on higher probability of receiving order or importance of demands. If new unpredicted demands come, then the managers need to add in to the plan and estimate the probability of receiving order and re-measure the workload and capacity for each discipline. The outcome of medium-term human resource allocation plan is input for the short-term human resource allocation plan.

In the short-term allocation plan, engineers are responsible to update their time sheet to provide the visibility of their workload and availability in a good condition. Engineering managers should monitor and control engineer's workload and set a short team meeting every week to review engineer's assignments. If engineers are over allocated or have no enough job to do or any other challenges related to projects and assigned tasks need to be discussed in this meeting and project manager is responsible to find a proper solution and solve a problem.




Links between various human resources allocation processes

As it shown in the above figure, the big cycle called "long-term human resource plan and allocation" and need to be updated and reported once a year by Department managers, HR department and engineering managers. The outcome of this process will be input for medium-term plan and allocation. The cycle in the middle called "Medium-term human resource plan and allocation" and every quarter need to be updated and reported by department managers and engineering managers. The outcome of this process will be input for short-term plan and allocation. The smallest cycle called "Short-term human resource plan and allocation" and engineers responsible to update it every day and every week and engineering managers responsible to control, monitor and report it.

Each process has its own steps such as:

- Set the regular meeting with management team and discuss on issues and take proper decision.
- Managers need to prepare uncertainties table and risk matrix and keep them update time to time
- The plan databases for the long-term, medium-term and short-term need to be updated by managers time to time
- Human resources dedication profile need to be generated and updated by the engineering managers time to time
- The plans need to be monitored, measured, evaluated and analyzed time to time
- If there is any failure or risk in the process or reports, management team need to take corrective or preventive action.

### *5.5 Feedback*

To make human resources allocation plan more effective, it is necessary to evaluate this process in regular base and improve it when needed. At the end of a year management team should review and evaluate the performance of human resources allocation process to check whether it worked effectively and met the requirements or not. They should analysis the process and the performance of the system to recognize and discover the strengths and weaknesses and find suitable solution to improve them to make system works better and efficient.

## 6. Roles & Responsibilities

| Key Role | Responsibility |
|---|---|
| Engineering Managers | Ensure all employees who require access to the database have the correct level of access in their accounts. Ensure all mandatory coding is against all resources using Timesheets. De-activate resource where required. Assign all new employees to the correct Timesheet. |
| Engineering Operations | Ensure all employees who require access to the database have the correct level of access in their accounts. Ensure all mandatory coding is against all resources using Timesheets. De-activate resource where required. Assign all new employees to the correct Timesheet. |
| Project Planner | Ensure all Human resources are assigned and closed out from project schedules. |

## 7. Quality Records

The following records produced by this procedure/work instruction are considered Quality Records and shall be maintained and controlled according to the requirements in OGQ-0102 - Record Control.

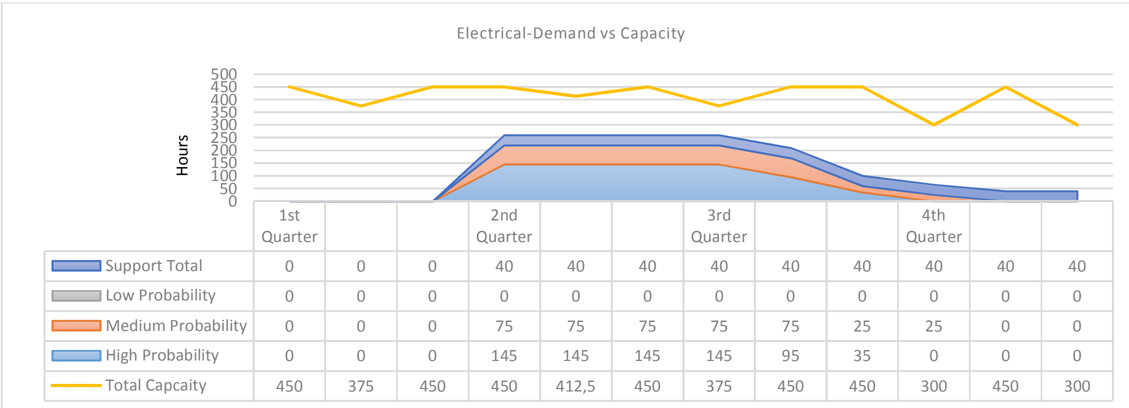
## 8. References

- GE O&G QMS Lexicon
- OGQ-0102 - Record Control Procedure
- Master thesis: Human resources planning, allocation and scheduling method in complex multi-project environment

## 9. Compliance Requirements

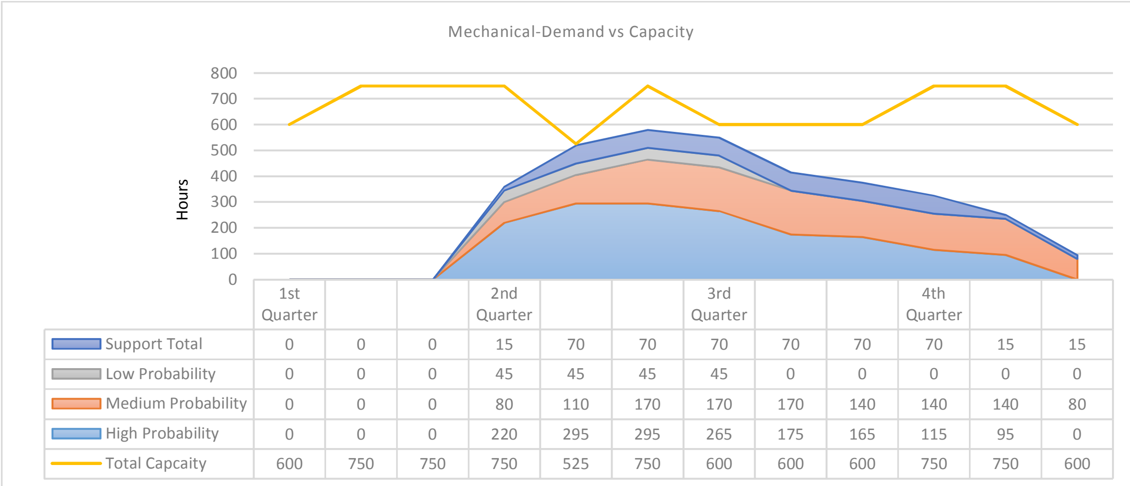
| | |
|---|---|
| Title: | Human resources planning and allocation method in complex multi-project environment |
| Reference : | QW-SS-GLO-PLN-008 |
| Revision: | 0.0 |
| Application Date : | 17.05.2018 |
| Expiration Date : | 18.05.2021 |
| Author: | |
| Eternal Refrenches : | Master thesis: Human resources planning, allocation and scheduling method in complex multi-project environment |

# Appendix B. Quarter demand versus capacity Quarter Demand vs Capacity in medium term allocation plan for each discipline



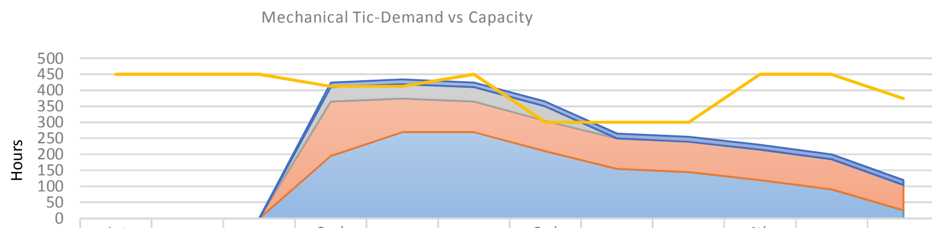

| Quarter | | 1st Quarter | | | 2nd Quarter | | | 3rd Quarter | | | 4th Quarter | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | | jan.18 | feb.18 | mar.18 | apr.18 | mai.18 | jun.18 | jul.18 | aug.18 | sep.18 | okt.18 | nov.18 | des.18 | Hours |
| Forecast Total | | | | | | | | | | | | | | |
| Ownership | Project | 0 | 0 | 0 | 220 | 220 | 220 | 220 | 170 | 60 | 25 | 0 | 0 | 1135 |
| High Probability | | 0 | 0 | 0 | 145 | 145 | 145 | 145 | 95 | 35 | 0 | 0 | 0 | 710 |
| Hymech | AkerBP Skarv Project | | | | 15 | 15 | 15 | 15 | 15 | 15 | | | | 90 |
| Tic | Troll concept study | | | | 20 | 20 | 20 | 20 | 20 | 20 | | | | 120 |
| Electrical | T/V ROV | | | | 110 | 110 | 110 | 110 | 60 | | | | | 500 |
| | | | | | | | | | | | | | | 0 |
| | | | | | | | | | | | | | | 0 |
| Medium Probability | | 0 | 0 | 0 | 75 | 75 | 75 | 75 | 75 | 25 | 25 | 0 | 0 | 425 |
| Electrical | Skarv Control System | | | | 75 | 75 | 75 | 75 | 75 | 25 | 25 | | | 425 |
| | | | | | | | | | | | | | | 0 |
| Low Probability | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | | 0 |
| | | | | | | | | | | | | | | 0 |
| Support Total | | | | | | | | | | | | | | |
| Ownership | Project | 0 | 0 | 0 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 360 |
| Electrical | Workshop support | | | | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 360 |
| | | | | | | | | | | | | | | 0 |
| Human resources | | | | | | | | | | | | | | |
| Available Employees | | 3 | 2,5 | 3 | 3 | 2,75 | 3 | 2,5 | 3 | 3 | 2 | 3 | 2 | 32,75 |
| Available Contractors | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Demand | | 0 | 0 | 0 | 260 | 260 | 260 | 260 | 210 | 100 | 65 | 40 | 40 | 1495 |
| Total Capacity | | 450 | 375 | 450 | 450 | 412,5 | 450 | 375 | 450 | 450 | 300 | 450 | 300 | 4913 |
| Demand Capacity Gap | | 450 | 375 | 450 | 190 | 152,5 | 190 | 115 | 240 | 350 | 235 | 410 | 260 | 3418 |

Quarter demand versus capacity for each discipline




| Quarter | | 1st Quarter | | | 2nd Quarter | | | 3rd Quarter | | | 4th Quarter | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | | jan.18 | feb.18 | mar.18 | apr.18 | mai.18 | jun.18 | jul.18 | aug.18 | sep.18 | okt.18 | nov.18 | des.18 | Hours |
| Forecast Total | | | | | | | | | | | | | | |
| Ownership | Project | 0 | 0 | 0 | 345 | 450 | 510 | 480 | 345 | 305 | 255 | 235 | 80 | 3005 |
| High Probability | | 0 | 0 | 0 | 220 | 295 | 295 | 265 | 175 | 165 | 115 | 95 | 0 | 1625 |
| Tic | Skarv ROV Panel Project | | | | 150 | 150 | 150 | 120 | 100 | 100 | 85 | 85 | | 940 |
| Tic | Troll concept study | | | | 20 | 20 | 20 | 20 | 20 | 20 | | | | 120 |
| XT-Tool | SNB FD015-K111 | | | | 35 | 35 | 35 | 35 | 35 | 25 | 10 | 10 | | 220 |
| XT-Tool | SNB Design Pressure | | | | | 75 | 75 | 75 | 20 | 20 | 20 | | | 285 |
| XT-Tool | Balder Phase 1 | | | | 15 | 15 | 15 | 15 | | | | | | 60 |
| Medium Probability | | 0 | 0 | 0 | 80 | 110 | 170 | 170 | 170 | 140 | 140 | 140 | 80 | 1200 |
| XT-Tool | T/V SLS | | | | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 720 |
| XT-Tool | T/V PEL Refurbishment | | | | | 30 | 30 | 30 | 30 | | | | | 120 |
| Tic | T/V System Modification | | | | | | 60 | 60 | 60 | 60 | 60 | 60 | | 360 |
| | | | | | | | | | | | | | | 0 |
| Low Probability | | 0 | 0 | 0 | 45 | 45 | 45 | 45 | 0 | 0 | 0 | 0 | 0 | 180 |
| XT-Tool | SNO Flowmeter | | | | 45 | 45 | 45 | 45 | | | | | | 180 |
| | | | | | | | | | | | | | | 0 |
| Support Total | | | | | | | | | | | | | | |
| Ownership | Project | 0 | 0 | 0 | 15 | 70 | 70 | 70 | 70 | 70 | 70 | 15 | 15 | 465 |
| XT-Tool | Adhoc Support | | | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 135 |
| XT-Tool | P/L XT-Tool | | | | | 55 | 55 | 55 | 55 | 55 | 55 | | | 330 |
| | | | | | | | | | | | | | | 0 |
| Human resources | | | | | | | | | | | | | | |
| Available Employees | | 4 | 5 | 5 | 5 | 3,5 | 5 | 4 | 4 | 4 | 5 | 5 | 4 | 53,5 |
| Available Contractors | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Demand | | 0 | 0 | 0 | 360 | 520 | 580 | 550 | 415 | 375 | 325 | 250 | 95 | 3470 |
| Total Capacity | | 600 | 750 | 750 | 750 | 525 | 750 | 600 | 600 | 600 | 750 | 750 | 600 | 8025 |
| Demand Capacity Gap | | 600 | 750 | 750 | 390 | 5 | 170 | 50 | 185 | 225 | 425 | 500 | 505 | 4555 |

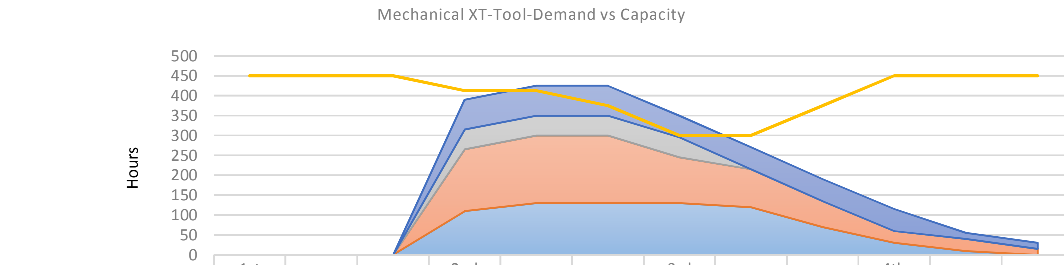
Quarter demand versus capacity for each discipline




| | 1st Quarter | | | 2nd Quarter | | | 3rd Quarter | | | 4th Quarter | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Support Total | 0 | 0 | 0 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Low Probability | 0 | 0 | 0 | 45 | 45 | 45 | 45 | 0 | 0 | 0 | 0 | 0 |
| Medium Probability | 0 | 0 | 0 | 170 | 105 | 95 | 95 | 95 | 95 | 95 | 95 | 80 |
| High Probability | 0 | 0 | 0 | 195 | 270 | 270 | 210 | 155 | 145 | 120 | 90 | 25 |
| Total Capcaity | 450 | 450 | 450 | 412,5 | 412,5 | 450 | 300 | 300 | 300 | 450 | 450 | 375 |

| Quarter | | 1st Quarter | | | 2nd Quarter | | | 3rd Quarter | | | 4th Quarter | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | | jan.18 | feb.18 | mar.18 | apr.18 | mai.18 | jun.18 | jul.18 | aug.18 | sep.18 | okt.18 | nov.18 | des.18 | Hours |
| Forecast Total | | | | | | | | | | | | | | |
| Ownership | Project | 0 | 0 | 0 | 410 | 420 | 410 | 350 | 250 | 240 | 215 | 185 | 105 | 2585 |
| High Probability | | 0 | 0 | 0 | 195 | 270 | 270 | 210 | 155 | 145 | 120 | 90 | 25 | 1480 |
| Tic | Skarv ROV Panel Project | | | | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | | 440 |
| Tic | Troll concept study | | | | 40 | 40 | 40 | 20 | 20 | 20 | 10 | | | 190 |
| Tic | SNB Markup Drawing | | | | 35 | 35 | 35 | 35 | 35 | 25 | 10 | 10 | | 220 |
| Tic | SNO THERT | | | | | 75 | 75 | 75 | 20 | 20 | 20 | | | 285 |
| Tic | T/V Check Valves | | | | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 225 |
| Hymech | Aker BP Skarv Project | | | | 40 | 40 | 40 | | | | | | | 120 |
| | | | | | | | | | | | | | | 0 |
| Medium Probability | | 0 | 0 | 0 | 170 | 105 | 95 | 95 | 95 | 95 | 95 | 95 | 80 | 925 |
| Tic | T/V System Modification | | | | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 720 |
| Tic | SNB PCDM Project | | | | 90 | 10 | | | | | | | | 100 |
| Tic | SNB Rental Tools | | | | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | | 105 |
| | | | | | | | | | | | | | | 0 |
| Low Probability | | 0 | 0 | 0 | 45 | 45 | 45 | 45 | 0 | 0 | 0 | 0 | 0 | 180 |
| Tic | Troll SSA AOB | | | | 45 | 45 | 45 | 45 | | | | | | 180 |
| | | | | | | | | | | | | | | 0 |
| Support Total | | | | | | | | | | | | | | |
| Ownership | Project | 0 | 0 | 0 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 135 |
| Tic | Tic Adhoc Support | | | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 135 |
| | | | | | | | | | | | | | | 0 |
| Human resources | | | | | | | | | | | | | | |
| Available Employees | | 3 | 3 | 3 | 2,75 | 2,75 | 3 | 2 | 2 | 2 | 3 | 3 | 2,5 | 32 |
| Available Contractors | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Demand | | 0 | 0 | 0 | 425 | 435 | 425 | 365 | 265 | 255 | 230 | 200 | 120 | 2720 |
| Total Capacity | | 450 | 450 | 450 | 412,5 | 412,5 | 450 | 300 | 300 | 300 | 450 | 450 | 375 | 4800 |
| Demand Capacity Gap | | 450 | 450 | 450 | -12,5 | -22,5 | 25 | -65 | 35 | 45 | 220 | 250 | 255 | 2080 |

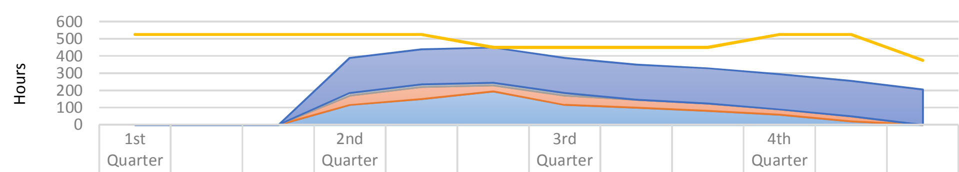
Quarter demand versus capacity for each discipline




| | 1st Quarter | | | 2nd Quarter | | | 3rd Quarter | | | 4th Quarter | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Support Total | 0 | 0 | 0 | 75 | 75 | 75 | 55 | 55 | 55 | 55 | 15 | 15 |
| Low Probability | 0 | 0 | 0 | 50 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 |
| Medium Probability | 0 | 0 | 0 | 155 | 170 | 170 | 115 | 95 | 65 | 30 | 30 | 15 |
| High Probability | 0 | 0 | 0 | 110 | 130 | 130 | 130 | 120 | 70 | 30 | 10 | 0 |
| Total Capcaity | 450 | 450 | 450 | 412,5 | 412,5 | 375 | 300 | 300 | 375 | 450 | 450 | 450 |

| Quarter | | 1st Quarter | | | 2nd Quarter | | | 3rd Quarter | | | 4th Quarter | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | | jan.18 | feb.18 | mar.18 | apr.18 | mai.18 | jun.18 | jul.18 | aug.18 | sep.18 | okt.18 | nov.18 | des.18 | Hours |
| Forecast Total | | | | | | | | | | | | | | |
| Ownership | Project | 0 | 0 | 0 | 315 | 350 | 350 | 295 | 215 | 135 | 60 | 40 | 15 | 1775 |
| High Probability | | 0 | 0 | 0 | 110 | 130 | 130 | 130 | 120 | 70 | 30 | 10 | 0 | 730 |
| Tic | Skarv ROV Panel Project | | | | 50 | 50 | 50 | 50 | 50 | | | | | 250 |
| Tic | Troll concept study | | | | 20 | 20 | 20 | 20 | 20 | 20 | | | | 120 |
| XT-Tool | SNB FD015-K111 | | | | 30 | 30 | 30 | 30 | 30 | 30 | 10 | 10 | | 200 |
| XT-Tool | SNB Design Pressure | | | | | 20 | 20 | 20 | 20 | 20 | 20 | | | 120 |
| XT-Tool | Balder Phase 1 | | | | 10 | 10 | 10 | 10 | | | | | | 40 |
| Medium Probability | | 0 | 0 | 0 | 155 | 170 | 170 | 115 | 95 | 65 | 30 | 30 | 15 | 845 |
| XT-Tool | T/V SLS | | | | 55 | 55 | 55 | 55 | 35 | 30 | 20 | 20 | 15 | 340 |
| XT-Tool | T/V PEL Refurbishment | | | | | 15 | 15 | 15 | 15 | | | | | 60 |
| Tic | T/V System Modification | | | | 65 | 65 | 65 | 35 | 35 | 35 | 10 | 10 | | 320 |
| Electrical | T/V ROV | | | | 35 | 35 | 35 | 10 | 10 | | | | | 125 |
| Low Probability | | 0 | 0 | 0 | 50 | 50 | 50 | 50 | 0 | 0 | 0 | 0 | 0 | 200 |
| XT-Tool | SNO Flowmeter | | | | 50 | 50 | 50 | 50 | | | | | | 200 |
| | | | | | | | | | | | | | | 0 |
| Support Total | | | | | | | | | | | | | | |
| Ownership | Project | 0 | 0 | 0 | 75 | 75 | 75 | 55 | 55 | 55 | 55 | 15 | 15 | 475 |
| XT-Tool | Adhoc Support | | | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 135 |
| XT-Tool | P/L XT-Tool | | | | 60 | 60 | 60 | 40 | 40 | 40 | 40 | | | 340 |
| | | | | | | | | | | | | | | 0 |
| Human resources | | | | | | | | | | | | | | |
| Available Employees | | 3 | 3 | 3 | 2,75 | 2,75 | 2,5 | 2 | 2 | 2,5 | 3 | 3 | 3 | 32,5 |
| Available Contractors | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Demand | | 0 | 0 | 0 | 390 | 425 | 425 | 350 | 270 | 190 | 115 | 55 | 30 | 2250 |
| Total Capacity | | 450 | 450 | 450 | 412,5 | 412,5 | 375 | 300 | 300 | 375 | 450 | 450 | 450 | 4875 |
| Demand Capacity Gap | | 450 | 450 | 450 | 22,5 | -12,5 | -50 | -50 | 30 | 185 | 335 | 395 | 420 | 2625 |

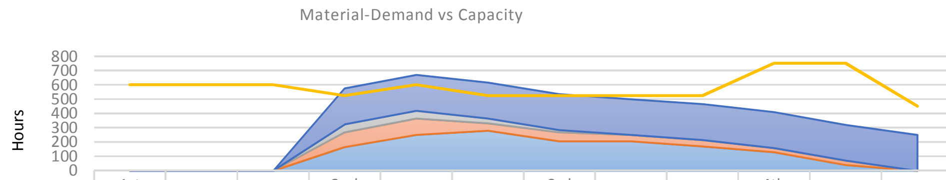
Quarter demand versus capacity for each discipline




| | 1st Quarter | | | 2nd Quarter | | | 3rd Quarter | | | 4th Quarter | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Support Total | 0 | 0 | 0 | 205 | 205 | 205 | 205 | 205 | 205 | 205 | 205 | 205 |
| Low Probability | 0 | 0 | 0 | 15 | 15 | 15 | 15 | 0 | 0 | 0 | 0 | 0 |
| Medium Probability | 0 | 0 | 0 | 55 | 70 | 35 | 55 | 45 | 45 | 30 | 30 | 0 |
| High Probability | 0 | 0 | 0 | 115 | 150 | 195 | 115 | 100 | 80 | 60 | 20 | 0 |
| Total Capcaity | 525 | 525 | 525 | 525 | 525 | 450 | 450 | 450 | 450 | 525 | 525 | 375 |

| Quarter | | 1st Quarter | | | 2nd Quarter | | | 3rd Quarter | | | 4th Quarter | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | | jan.18 | feb.18 | mar.18 | apr.18 | mai.18 | jun.18 | jul.18 | aug.18 | sep.18 | okt.18 | nov.18 | des.18 | Hours |
| **Forecast Total** | | | | | | | | | | | | | | |
| **Ownership** | **Project** | **0** | **0** | **0** | **185** | **235** | **245** | **185** | **145** | **125** | **90** | **50** | **0** | **1260** |
| High Probability | | 0 | 0 | 0 | 115 | 150 | 195 | 115 | 100 | 80 | 60 | 20 | 0 | 835 |
| Tic | Skarv ROV Panel Project | | | | | | 45 | 20 | 20 | 20 | 20 | 20 | | 145 |
| Tic | Troll concept study | | | | 35 | 35 | 35 | 15 | 15 | 10 | 10 | | | 155 |
| Tic | SNB Markup Drawing | | | | 10 | 10 | 10 | 10 | 5 | | | | | 45 |
| Tic | SNO THERT | | | | | 20 | 20 | 20 | 10 | 10 | 5 | | | 85 |
| Tic | T/V Check Valves | | | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | | | 105 |
| Hymech | AkerBP Skarv Project | | | | 35 | 35 | 35 | | | | | | | 105 |
| XT-Tool | SNB FD015-K111 | | | | 20 | 20 | 20 | 20 | 20 | 10 | 10 | | | 120 |
| XT-Tool | SNB Design Pressure | | | | | 15 | 15 | 15 | 15 | 15 | | | | 75 |
| Medium Probability | | 0 | 0 | 0 | 55 | 70 | 35 | 55 | 45 | 45 | 30 | 30 | 0 | 365 |
| Tic | T/V System Modification | | | | 10 | 10 | 10 | 10 | | | | | | 40 |
| Tic | SNB PCDM Project | | | | 10 | 10 | | | | | | | | 20 |
| Tic | SNB Rental Tools | | | | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | | 105 |
| XT-Tool | T/V SLS | | | | 35 | 35 | 10 | 30 | 30 | 30 | 15 | 15 | | 200 |
| Low Probability | | 0 | 0 | 0 | 15 | 15 | 15 | 15 | 0 | 0 | 0 | 0 | 0 | 60 |
| Tic | Troll SSA AOB | | | | 10 | 10 | 10 | 10 | | | | | | 40 |
| XT-Tool | SNO Flowmeter | | | | 5 | 5 | 5 | 5 | | | | | | 20 |
| **Support Total** | | | | | | | | | | | | | | |
| **Ownership** | **Project** | **0** | **0** | **0** | **205** | **205** | **205** | **205** | **205** | **205** | **205** | **205** | **205** | **1845** |
| Analysis | Tools & XT Analysis Support | | | | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 315 |
| Analysis | Analysis Support Surface | | | | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 630 |
| Analysis | Analysis Adhoc Support | | | | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 900 |
| **Human resources** | | | | | | | | | | | | | | |
| Available Employees | | 3 | 3 | 3 | 3 | 3 | 2,5 | 2,5 | 2,5 | 2,5 | 3 | 3 | 2 | 33 |
| Available Contractors | | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 6 |
| Total Demand | | **0** | **0** | **0** | **390** | **440** | **450** | **390** | **350** | **330** | **295** | **255** | **205** | **3105** |
| Total Capacity | | **525** | **525** | **525** | **525** | **525** | **450** | **450** | **450** | **450** | **525** | **525** | **375** | **5850** |
| Demand Capacity Gap | | **525** | **525** | **525** | **135** | **85** | **0** | **60** | **100** | **120** | **230** | **270** | **170** | **2745** |

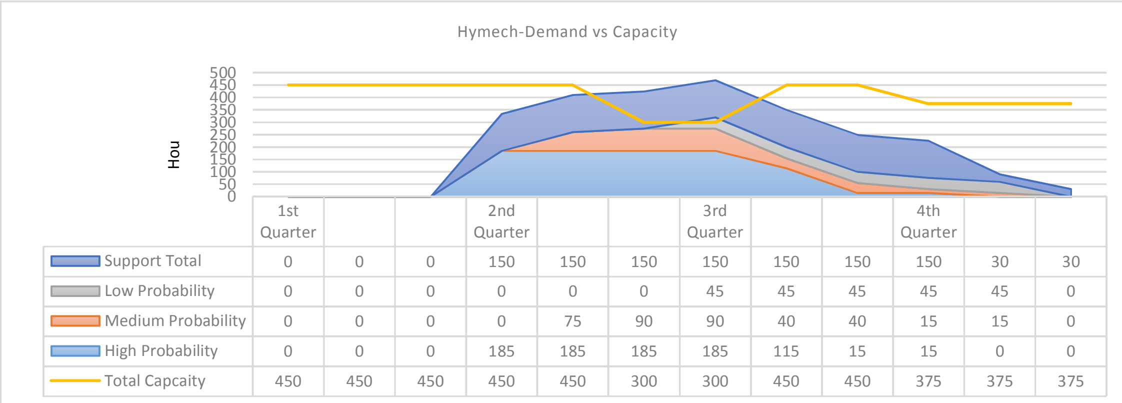
Quarter demand versus capacity for each discipline




| | 1st Quarter | | | 2nd Quarter | | | 3rd Quarter | | | 4th Quarter | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Support Total | 0 | 0 | 0 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| Low Probability | 0 | 0 | 0 | 55 | 55 | 35 | 15 | 0 | 0 | 0 | 0 | 0 |
| Medium Probability | 0 | 0 | 0 | 105 | 115 | 50 | 65 | 45 | 45 | 30 | 30 | 0 |
| High Probability | 0 | 0 | 0 | 165 | 250 | 280 | 205 | 205 | 170 | 130 | 40 | 0 |
| Total Capcaity | 600 | 600 | 600 | 525 | 600 | 525 | 525 | 525 | 525 | 750 | 750 | 450 |

| Quarter | | 1st Quarter | | | 2nd Quarter | | | 3rd Quarter | | | 4th Quarter | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | | jan.18 | feb.18 | mar.18 | apr.18 | mai.18 | jun.18 | jul.18 | aug.18 | sep.18 | okt.18 | nov.18 | des.18 | Hours |
| Forecast Total | | | | | | | | | | | | | | |
| Ownership | Project | 0 | 0 | 0 | 325 | 420 | 365 | 285 | 250 | 215 | 160 | 70 | 0 | 2090 |
| High Probability | | 0 | 0 | 0 | 165 | 250 | 280 | 205 | 205 | 170 | 130 | 40 | 0 | 1445 |
| Tic | Skarv ROV Panel Project | | | | | 20 | 50 | 40 | 40 | 40 | 40 | 40 | | 270 |
| Tic | Troll concept study | | | | 50 | 55 | 55 | 35 | 35 | 35 | 30 | | | 295 |
| Tic | SNB Markup Drawing | | | | 25 | 25 | 25 | 15 | 10 | | | | | 100 |
| Tic | SNO THERT | | | | | 30 | 30 | 30 | 35 | 15 | 10 | | | 150 |
| Tic | T/V Check Valves | | | | 30 | 30 | 30 | 30 | 30 | 30 | 30 | | | 210 |
| Hymech | AkerBP Skarv Project | | | | 35 | 35 | 35 | | | | | | | 105 |
| XT-Tool | SNB FD015-K111 | | | | 25 | 25 | 25 | 25 | 25 | 20 | 20 | | | 165 |
| XT-Tool | SNB Design Pressure | | | | | 30 | 30 | 30 | 30 | 30 | | | | 150 |
| Medium Probability | | 0 | 0 | 0 | 105 | 115 | 50 | 65 | 45 | 45 | 30 | 30 | 0 | 485 |
| Tic | T/V System Modification | | | | 30 | 25 | 25 | 20 | | | | | | 100 |
| Tic | SNB PCDM Project | | | | 40 | 40 | | | | | | | | 80 |
| Tic | SNB Rental Tools | | | | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | | 105 |
| XT-Tool | T/V SLS | | | | 35 | 35 | 10 | 30 | 30 | 30 | 15 | 15 | | 200 |
| Low Probability | | 0 | 0 | 0 | 55 | 55 | 35 | 15 | 0 | 0 | 0 | 0 | 0 | 160 |
| Tic | Troll SSA AOB | | | | 30 | 30 | 10 | 10 | | | | | | 80 |
| XT-Tool | SNO Flowmeter | | | | 25 | 25 | 25 | 5 | | | | | | 80 |
| Support Total | | | | | | | | | | | | | | |
| Ownership | Project | 0 | 0 | 0 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 2250 |
| Material | Tools & XT Material Support | | | | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 450 |
| Material | Material Support Workshop | | | | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 900 |
| Material | Material Adhoc Support | | | | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 900 |
| Human resources | | | | | | | | | | | | | | |
| Available Employees | | 4 | 4 | 4 | 3,5 | 4 | 3,5 | 3,5 | 3,5 | 3,5 | 5 | 5 | 3 | 46,5 |
| Available Contractors | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Demand | | 0 | 0 | 0 | 575 | 670 | 615 | 535 | 500 | 465 | 410 | 320 | 250 | 4340 |
| Total Capacity | | 600 | 600 | 600 | 525 | 600 | 525 | 525 | 525 | 525 | 750 | 750 | 450 | 6975 |
| Demand Capacity Gap | | 600 | 600 | 600 | -50 | -70 | -90 | -10 | 25 | 60 | 340 | 430 | 200 | 2635 |

Quarter demand versus capacity for each discipline

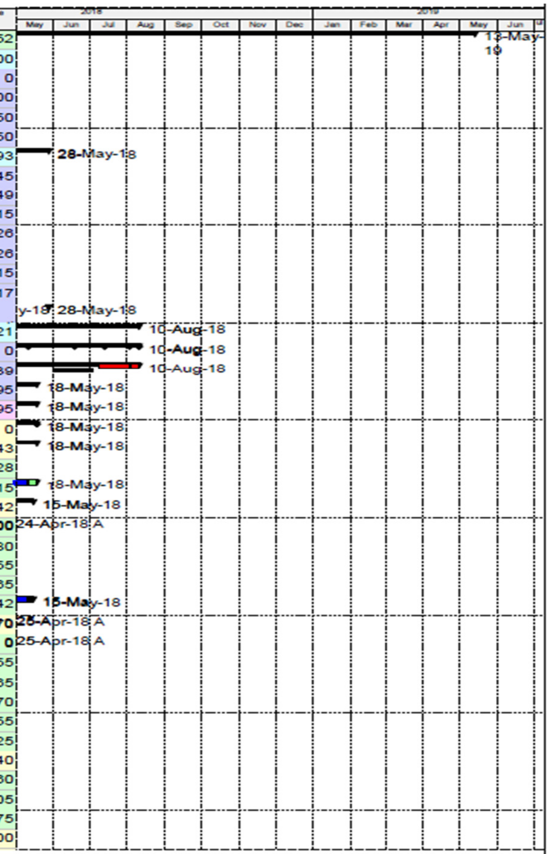



| Quarter | | 1st Quarter | | | 2nd Quarter | | | 3rd Quarter | | | 4th Quarter | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | | jan.18 | feb.18 | mar.18 | apr.18 | mai.18 | jun.18 | jul.18 | aug.18 | sep.18 | okt.18 | nov.18 | des.18 | Hours |
| **Forecast Total** | | | | | | | | | | | | | | |
| **Ownership** | **Project** | **0** | **0** | **0** | **185** | **260** | **275** | **320** | **200** | **100** | **75** | **60** | **0** | **1475** |
| High Probability | | 0 | 0 | 0 | 185 | 185 | 185 | 185 | 115 | 15 | 15 | 0 | 0 | 885 |
| Hymech | AkerBP Skarv Project | | | | 100 | 100 | 100 | 100 | 100 | | | | | 500 |
| Tic | Troll concept study | | | | 60 | 60 | 60 | 60 | | | | | | 240 |
| XT-Tool | SNB Design Pressure | | | | 15 | 15 | 15 | 15 | 15 | 15 | 15 | | | 105 |
| XT-Tool | Balder Phase 1 | | | | 10 | 10 | 10 | 10 | | | | | | 40 |
| | | | | | | | | | | | | | | 0 |
| Medium Probability | | 0 | 0 | 0 | 0 | 75 | 90 | 90 | 40 | 40 | 15 | 15 | 0 | 365 |
| Hymech | SNB Subsea Project | | | | | 50 | 50 | 50 | | | | | | 150 |
| Electrical | Skarv Control System | | | | | 25 | 25 | 25 | 25 | 25 | | | | 125 |
| Tic | T/V System Modification | | | | | | 15 | 15 | 15 | 15 | 15 | 15 | | 90 |
| | | | | | | | | | | | | | | 0 |
| Low Probability | | 0 | 0 | 0 | 0 | 0 | 0 | 45 | 45 | 45 | 45 | 45 | 0 | 225 |
| Hymech | Troll BB015 | | | | | | | 45 | 45 | 45 | 45 | 45 | | 225 |
| | | | | | | | | | | | | | | 0 |
| **Support Total** | | | | | | | | | | | | | | |
| **Ownership** | **Project** | **0** | **0** | **0** | **150** | **150** | **150** | **150** | **150** | **150** | **150** | **30** | **30** | **1110** |
| Hymech | P/L Offshore support | | | | 120 | 120 | 120 | 120 | 120 | 120 | 120 | | | 840 |
| Hymech | P/L PCS/Choke | | | | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 270 |
| | | | | | | | | | | | | | | 0 |
| | | | | | | | | | | | | | | 0 |
| **Human resources** | | | | | | | | | | | | | | |
| Available Employees | | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 22 |
| Available Contractors | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0,5 | 0,5 | 0,5 | 10,5 |
| Total Demand | | **0** | **0** | **0** | **335** | **410** | **425** | **470** | **350** | **250** | **225** | **90** | **30** | **2585** |
| Total Capacity | | **450** | **450** | **450** | **450** | **450** | **300** | **300** | **450** | **450** | **375** | **375** | **375** | **4875** |
| Demand Capacity Gap | | **450** | **450** | **450** | **115** | **40** | **-125** | **-170** | **100** | **200** | **150** | **285** | **345** | **2290** |

Quarter demand versus capacity for each discipline

# Appendix C. Example of Multi-project plans

| Activity Name | Original Duration | Planed % Complete | Actual % Complete | BL Project Start | BL Project Finish | Start | Finish | Budgeted Labor Units | Earned Value Labor Units |
|---|---|---|---|---|---|---|---|---|---|
| Total | 2206 | 66.73% | 66.15% | 24-Jul-14 | 06-Jun-19 | 24-Jul-14 A | 13-May-19 | 133661 | 83952 |
| MCS Rental Equipment | 503 | 100% | 100% | 02-Jan-17 | 02-Jan-18 | 02-Jan-17 A | 02-Jan-18 | 2000 | 2000 |
| Milestones | 510 | 0% | 0% | 02-Jan-17 | 02-Jan-18 | 02-Jan-17 A | 02-Jan-18 | 0 | 0 |
| Project Management | 250 | 100% | 100% | 02-Jan-17 | 29-Dec-17 | 02-Jan-17 A | 29-Dec-17 | 1000 | 1000 |
| Engineering | 250 | 100% | 100% | 02-Jan-17 | 29-Dec-17 | 02-Jan-17 A | 29-Dec-17 | 250 | 250 |
| Workshop | 250 | 100% | 100% | 02-Jan-17 | 29-Dec-17 | 02-Jan-17 A | 29-Dec-17 | 750 | 750 |
| Rental Tool / Assembly of 5 ea. URTs | 322 | 99.14% | 99.14% | 02-Feb-17 | 28-May-18 | 30-Jan-17 A | 28-May-18 | 295 | 293 |
| URT #1, H-005G | 7 | 100% | 100% | 02-Feb-17 | 10-Feb-17 | 30-Jan-17 A | 05-Feb-17 | 45 | 45 |
| URT #2, H-005A | 60 | 100% | 100% | 02-Feb-17 | 04-May-17 | 30-Jan-17 A | 02-May-17 | 49 | 49 |
| URT #3, H-005O | 81 | 100% | 100% | 23-Feb-17 | 29-Jun-17 | 16-Feb-17 A | 27-Jun-17 | 115 | 115 |
| URT #4, H-005I | 150 | 100% | 100% | 17-Feb-17 | 28-Sep-17 | 16-Feb-17 A | 21-Sep-17 | 26 | 26 |
| URT #5, H-005K | 215 | 100% | 100% | 17-Feb-17 | 29-Dec-17 | 16-Feb-17 A | 13-Dec-17 | 26 | 26 |
| URT Test Mandrel, H-030D | 60 | 100% | 100% | 23-Mar-17 | 27-Jun-17 | 23-Mar-17 A | 12-Jun-17 | 15 | 15 |
| URT Test & handling cap, H-031K | 17 | 100% | 100% | 15-Jun-17 | 07-Jul-17 | 15-Jun-17 A | 04-Jul-17 A | 17 | 17 |
| Assembly of Slick Jt Adapter | 1 | 0% | 0% | 28-May-18 | 28-May-18 | 28-May-18 | 28-May-18 | 3 S | |
| DIACS Modification | 487 | 79.31% | 76.5% | 22-May-17 | 03-Jul-18 | 22-May-17 A | 10-Aug-18 | 15253 | 13621 |
| Milestones | 308 | 0% | 0% | 22-May-17 | 03-Jul-18 | 22-May-17 A | 10-Aug-18 | 0 | 0 |
| WP01- Project Management | 308 | 82.58% | 82.58% | 22-May-17 | 03-Jul-18 | 22-May-17 A | 10-Aug-18 | 895 | 739 |
| WP02- Engineering | 249 | 100% | 98.92% | 22-May-17 | 28-Mar-18 | 22-May-17 A | 18-May-18 | 11030 | 10795 |
| Eng. WBS | 249 | 100% | 98.92% | 22-May-17 | 28-Mar-18 | 22-May-17 A | 18-May-18 | 11030 | 10795 |
| Milestones | 249 | 0% | 0% | 22-May-17 | 08-Feb-18 | 22-May-17 A | 18-May-18 | 0 | 0 |
| Solution | 195 | 100% | 99.26% | 22-May-17 | 28-Mar-18 | 22-May-17 A | 18-May-18 | 2073 | 2043 |
| Meetings | 1 | 100% | 100% | 31-May-17 | 31-May-17 | 23-Jun-17 A | 23-Jun-17 | 28 | 28 |
| Systems Engineering | 195 | 100% | 99.25% | 22-May-17 | 28-Mar-18 | 22-May-17 A | 18-May-18 | 2045 | 2015 |
| PCS | 194 | 100% | 96.68% | 09-Jun-17 | 15-Jan-18 | 09-Jun-17 A | 15-May-18 | 4117 | 3942 |
| SCM- AJX | 176 | 100% | 100% | 09-Jun-17 | 15-Jan-18 | 09-Jun-17 A | 24-Apr-18 A | 512 | 500 |
| Dummy SCM | 46 | 100% | 100% | 10-Aug-17 | 13-Oct-17 | 09-Jun-17 A | 12-Oct-17 A | 280 | 280 |
| SCM Test Stand | 37 | 100% | 100% | 10-Aug-17 | 02-Oct-17 | 09-Jun-17 A | 27-Oct-17 A | 255 | 255 |
| SCMMB | 23 | 100% | 100% | 25-Aug-17 | 27-Sep-17 | 04-Sep-17 A | 13-Oct-17 A | 165 | 165 |
| Outsourced | 187 | 100% | 94.39% | 20-Jun-17 | 27-Dec-17 | 20-Jun-17 A | 15-May-18 | 2905 | 2742 |
| XT | 154 | 100% | 100% | 22-May-17 | 06-Dec-17 | 09-Jun-17 A | 25-Apr-18 A | 1600 | 1570 |
| SCM MB | 8 | 0% | 0% | 22-May-17 | 01-Jun-17 | 04-Jan-18 A | 25-Apr-18 A | 30 | 0 |
| XMT- A | 91 | 100% | 100% | 24-Jul-17 | 28-Nov-17 | 15-Jun-17 A | 22-Dec-17 | 555 | 555 |
| XMT- B | 28 | 100% | 100% | 30-Oct-17 | 06-Dec-17 | 21-Nov-17 A | 22-Dec-17 | 165 | 165 |
| Tubing Hanger | 41 | 100% | 100% | 09-Jun-17 | 04-Aug-17 | 09-Jun-17 A | 24-Nov-17 | 370 | 370 |
| XMT Test Stump | 41 | 100% | 100% | 24-Jul-17 | 19-Sep-17 | 10-Aug-17 A | 13-Nov-17 | 255 | 255 |
| Tree Cap and Handling Caps | 34 | 100% | 100% | 15-Sep-17 | 01-Nov-17 | 25-Sep-17 A | 02-Nov-17 | 225 | 225 |
| Tools | 184 | 100% | 100% | 09-Jun-17 | 08-Feb-18 | 09-Jun-17 A | 07-Dec-17 | 2940 | 2940 |
| THROT | 56 | 100% | 100% | 09-Jun-17 | 25-Aug-17 | 03-Jul-17 A | 07-Dec-17 | 360 | 360 |
| THRT Test / Handling Cap | 94 | 100% | 100% | 02-Aug-17 | 11-Dec-17 | 11-Sep-17 A | 04-Dec-17 | 505 | 505 |
| SLS - DIACS | 184 | 100% | 100% | 09-Jun-17 | 08-Feb-18 | 09-Jun-17 A | 07-Dec-17 | 2075 | 2075 |
| Materials & Analysis | 184 | 100% | 100% | 22-May-17 | 08-Feb-18 | 22-May-17 A | 22-Dec-17 | 300 | 300 |




Actual Work
Critical Remaining Work
Second Baseline
Primary Baseline
Remaining Work
Milestone

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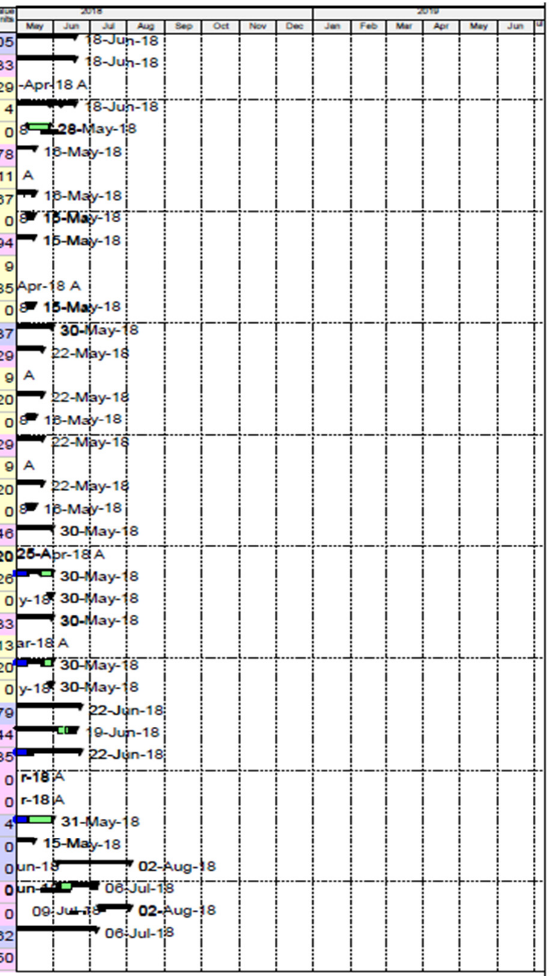
TASK filter: All Activities



Multi-project plans

| Activity Name | Original Duration | Planned % Complete | Actual % Complete | BL Project Start | BL Project Finish | Start | Finish | Budgeted Labor Units | Earned Value Labor Units |
|---|---|---|---|---|---|---|---|---|---|
| WP03- PCS procurement & WS | 316 | 96.33% | 91.7% | 29-Jun-17 | 04-Jun-18 | 23-Jun-17 A | 18-Jun-18 | 262 | 205 |
| WS SCM Production | 316 | 90.52% | 85.4% | 29-Jun-17 | 04-Jun-18 | 23-Jun-17 A | 18-Jun-18 | 60 | 33 |
| Procurement | 195 | 100% | 100% | 29-Jun-17 | 27-Nov-17 | 23-Jun-17 A | 11-Apr-18 A | 29 | 29 |
| Modification & Test | 152 | 49.31% | 9.91% | 18-Aug-17 | 18-May-18 | 08-Jan-18 A | 18-Jun-18 | 19 | 4 |
| MC & Documentation | 10 | 0% | 0% | 22-May-18 | 04-Jun-18 | 11-May-18 | 28-May-18 | 12 | 0 |
| WS Dummy SCM | 220 | 100% | 96.65% | 29-Jun-17 | 25-Jan-18 | 03-Jul-17 A | 16-May-18 | 96 | 78 |
| Procurement | 165 | 100% | 100% | 29-Jun-17 | 07-Dec-17 | 03-Jul-17 A | 22-Feb-18 | 11 | 11 |
| Modification & Test | 100 | 100% | 93.9% | 30-Aug-17 | 11-Jan-18 | 18-Dec-17 A | 16-May-18 | 71 | 67 |
| MC & Documentation | 3 | 100% | 0% | 11-Jan-18 | 25-Jan-18 | 11-May-18 | 15-May-18 | 14 | 0 |
| WS SCM Test stand | 219 | 100% | 93.02% | 29-Jun-17 | 17-Jan-18 | 03-Jul-17 A | 15-May-18 | 106 | 94 |
| Procurement | 134 | 100% | 100% | 29-Jun-17 | 28-Nov-17 | 03-Jul-17 A | 22-Dec-17 | 9 | 9 |
| Modification & Test | 73 | 100% | 100% | 31-Jul-17 | 02-Jan-18 | 18-Dec-17 A | 04-Apr-18 A | 83 | 85 |
| MC & Documentation | 3 | 100% | 0% | 03-Jan-18 | 17-Jan-18 | 11-May-18 | 15-May-18 | 14 | 0 |
| WP04- XT Procurement & WS | 228 | 100% | 89.41% | 22-May-17 | 26-Apr-18 | 03-Jul-17 A | 30-May-18 | 352 | 537 |
| WS TH & Procurement- TH #1 | 222 | 100% | 87.34% | 29-Jun-17 | 26-Apr-18 | 03-Jul-17 A | 22-May-18 | 40 | 129 |
| Procurement | 167 | 100% | 100% | 29-Jun-17 | 07-Dec-17 | 03-Jul-17 A | 23-Feb-18 | 9 | 9 |
| Modification & Test | 114 | 100% | 97.66% | 31-Jul-17 | 23-Apr-18 | 30-Nov-17 A | 22-May-18 | 16 | 120 |
| MC & Documentation | 4 | 100% | 0% | 12-Apr-18 | 26-Apr-18 | 11-May-18 | 16-May-18 | 15 | 0 |
| WS TH & Procurement- TH#2 | 222 | 100% | 87.34% | 22-May-17 | 26-Apr-18 | 03-Jul-17 A | 22-May-18 | 40 | 129 |
| Procurement | 167 | 100% | 100% | 29-Jun-17 | 07-Dec-17 | 03-Jul-17 A | 23-Feb-18 | 9 | 9 |
| Modification & Test | 114 | 100% | 97.66% | 22-May-17 | 23-Apr-18 | 30-Nov-17 A | 22-May-18 | 16 | 120 |
| MC & Documentation | 4 | 100% | 0% | 11-Apr-18 | 26-Apr-18 | 11-May-18 | 16-May-18 | 15 | 0 |
| WS XT & Procurement | 228 | 100% | 91.51% | 29-Jun-17 | 31-Jan-18 | 03-Jul-17 A | 30-May-18 | 193 | 246 |
| Procurement | 206 | 100% | 100% | 29-Jun-17 | 07-Dec-17 | 03-Jul-17 A | 25-Apr-18 A | 70 | 20 |
| Modification & Test | 124 | 100% | 68.79% | 29-Sep-17 | 17-Jan-18 | 24-Nov-17 A | 30-May-18 | 103 | 226 |
| MC & Documentation | 2 | 100% | 0% | 18-Jan-18 | 31-Jan-18 | 29-May-18 | 30-May-18 | 20 | 0 |
| WS XT test skid & Procurement | 228 | 100% | 78.3% | 29-Jun-17 | 08-Feb-18 | 03-Jul-17 A | 30-May-18 | 79 | 33 |
| Procurement | 187 | 100% | 100% | 29-Jun-17 | 07-Dec-17 | 03-Jul-17 A | 23-Mar-18 | 13 | 13 |
| Modification & Test | 120 | 100% | 42.86% | 07-Sep-17 | 26-Jan-18 | 30-Nov-17 A | 30-May-18 | 61 | 20 |
| MC & Documentation | 2 | 100% | 0% | 26-Jan-18 | 08-Feb-18 | 29-May-18 | 30-May-18 | 5 | 0 |
| WP05- Tools Procurement & WS | 245 | 100% | 86.25% | 29-Jun-17 | 19-Apr-18 | 03-Jul-17 A | 22-Jun-18 | 309 | 379 |
| WS THROT & Procurement | 242 | 100% | 55.29% | 29-Jun-17 | 06-Apr-18 | 03-Jul-17 A | 19-Jun-18 | 38 | 44 |
| WS SLS & Procurement | 245 | 100% | 91.44% | 29-Jun-17 | 19-Apr-18 | 03-Jul-17 A | 22-Jun-18 | 271 | 335 |
| WS XT T/H Cap & Procurement | 184 | 0% | 0% | 29-Jun-17 | 31-Jan-18 | 03-Jul-17 A | 20-Mar-18 | 0 | 0 |
| WS THRT T/H Cap & Procurement | 184 | 0% | 0% | 29-Jun-17 | 10-Apr-18 | 03-Jul-17 A | 20-Mar-18 | 0 | 0 |
| WP06- Third Party Procurement & WS | 197 | 100% | 92.73% | 21-Jul-17 | 09-Apr-18 | 28-Jul-17 A | 31-May-18 | 4 | 4 |
| WP07- Outsourced Procurement | 134 | 0% | 0% | 20-Jun-17 | 22-Dec-17 | 20-Jun-17 A | 15-May-18 | 0 | 0 |
| WP08- EFAT | 44 | 0% | 0% | 22-May-18 | 27-Jun-18 | 04-Jun-18 | 02-Aug-18 | 528 | 0 |
| Test & Shipment | 25 | 0% | 0% | 22-May-18 | 14-Jun-18 | 04-Jun-18 | 06-Jul-18 | 449 | 0 |
| MC & Documentation | 19 | 0% | 0% | 15-Jun-18 | 27-Jun-18 | 09-Jul-18 | 02-Aug-18 | 79 | 0 |
| Variation Orders | 305 | 94.8% | 91.18% | 04-Sep-17 | 21-Jun-18 | 04-Sep-17 A | 06-Jul-18 | 1874 | 962 |
| VOR001 - Annular Valve Modification | 20 | 100% | 100% | 04-Sep-17 | 29-Sep-17 | 04-Sep-17 A | 29-Sep-17 | 150 | 150 |



Actual Work | Critical Remaining Work | Second Baseline | Primary Baseline | Remaining Work | Milestone

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TASK filter: All Activities

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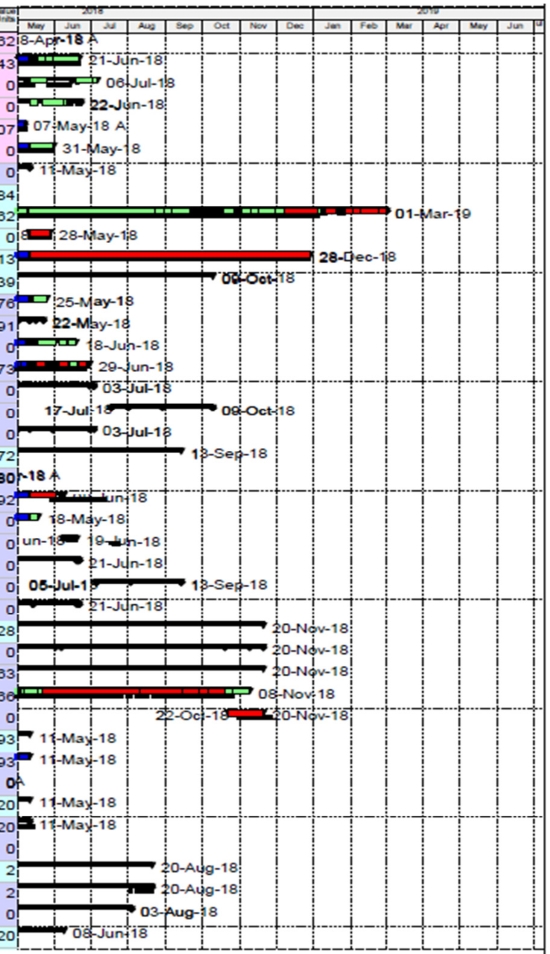
Multi-project plans

| Activity Name | Original Duration | Planned % Complete | Actual % Complete | BL Project Start | BL Project Finish | Start | Finish | Budgeted Labor Units | Earned Value Labor Units |
|---|---|---|---|---|---|---|---|---|---|
| VOR002 - SLS Basket +Manifold parts | 102 | 100% | 100% | 27-Nov-17 | 13-Apr-18 | 27-Nov-17 A | 18-Apr-18 A | 62 | 62 |
| VOR003 - Changes due to new Client input | 141 | 90.43% | 83.31% | 06-Dec-17 | 21-Jun-18 | 01-Nov-17 A | 21-Jun-18 | 857 | 643 |
| VOR004 - Simplified System Integration Test (S-SIT) | 148 | 0% | 0% | 16-Jan-18 | 14-Jun-18 | 18-Jan-18 A | 06-Jul-18 | 451 | 0 |
| VOR005 - Disassembly & Assembly/Test | 105 | 0% | 0% | 16-Jan-18 | 18-Apr-18 | 16-Jan-18 A | 22-Jun-18 | 0 | 0 |
| VOR006 - New Flowmeter | 72 | 100% | 100% | 26-Mar-18 | 09-May-18 | 26-Jan-18 A | 07-May-18 | 350 | 107 |
| VOR007 - Repair THRT | 67 | 84.12% | 25% | 27-Mar-18 | 31-May-18 | 19-Feb-18 A | 31-May-18 | 4 | 0 |
| Company Provided items | 243 | 0% | 0% | 22-May-17 | 16-Feb-18 | 22-May-17 A | 11-May-18 | 0 | 0 |
| Creation of repair part numbers for rental tools | 53 | 50.09% | 55.61% | 01-Dec-17 | 16-Feb-18 | 01-Dec-17 A | 16-Feb-18 | 330 | 184 |
| GS2 UTH Connections System | 452 | 9.63% | 8.28% | 18-Sep-17 | 04-Jan-19 | 18-Sep-17 A | 01-Mar-19 | 4802 | 162 |
| DIACS / Update of injection test | 10 | 0% | 0% | 11-May-18 | 28-May-18 | 11-May-18 | 28-May-18 | 15 | 0 |
| Engineering T&XT Support | 970 | 79.64% | 79.64% | 01-Jan-15 | 28-Dec-18 | 01-Jan-15 A | 28-Dec-18 | 4890 | 4513 |
| Refurb of XT OL | 449 | 62.76% | 49.04% | 17-Jul-17 | 23-Oct-18 | 17-Jul-17 A | 09-Oct-18 | 2706 | 1239 |
| Strip, Clean & Inspect | 213 | 100% | 97.36% | 17-Jul-17 | 06-Apr-18 | 17-Jul-17 A | 25-May-18 | 878 | 876 |
| Refurbishment & Upgrade | 123 | 100% | 93.95% | 20-Nov-17 | 06-Apr-18 | 18-Jan-18 A | 22-May-18 | 212 | 191 |
| VOR Findings after QCI | 84 | 0% | 0% | | | 08-Feb-18 A | 18-Jun-18 | 259 | 0 |
| Assembly/Test | 48 | 33.87% | 12.02% | 06-Apr-18 | 26-Jun-18 | 18-Apr-18 A | 29-Jun-18 | 1357 | 173 |
| MC/Documentation | 21 | 0% | 0% | 05-Jun-18 | 17-Jul-18 | 01-Nov-17 A | 03-Jul-18 | 0 | 0 |
| Project closure | 60 | 0% | 0% | 31-Jul-18 | 23-Oct-18 | 17-Jul-18 | 09-Oct-18 | 0 | 0 |
| Company Milestones | 120 | 0% | 0% | 30-Oct-17 | 17-Jul-18 | 22-Dec-17 A | 03-Jul-18 | 0 | 0 |
| Overhaul of TH | 230 | 49.06% | 53.09% | 11-Oct-17 | 02-Nov-18 | 11-Oct-17 A | 13-Sep-18 | 333 | 172 |
| Strip, Clean & Inspect | 123 | 100% | 100% | 11-Oct-17 | 26-Jan-18 | 11-Oct-17 A | 16-Mar-18 | 80 | 80 |
| Refurbishment, Upgrade & Repair | 84 | 68.28% | 79.1% | 17-Jan-18 | 13-Jul-18 | 07-Feb-18 A | 08-Jun-18 | 116 | 92 |
| Standard spares | 66 | 0% | 0% | 11-Oct-17 | 12-Apr-18 | 19-Dec-17 A | 18-May-18 | 0 | 0 |
| Assembly/Test | 8 | 0% | 0% | 13-Jul-18 | 24-Jul-18 | 08-Jun-18 | 19-Jun-18 | 92 | 0 |
| MC activities & Documentation | 56 | 0% | 0% | 15-Jun-18 | 10-Aug-18 | 19-Jan-18 A | 21-Jun-18 | 45 | 0 |
| Project closure | 50 | 0% | 0% | 24-Aug-18 | 02-Nov-18 | 05-Jul-18 | 13-Sep-18 | 0 | 0 |
| Company Milestones | 112 | 0% | 0% | 30-Nov-17 | 10-Aug-18 | 27-Dec-17 A | 21-Jun-18 | 0 | 0 |
| UTH Connections HCCS and FCM | 245 | 50.41% | 24.98% | 15-Dec-17 | 27-Nov-18 | 15-Dec-17 A | 20-Nov-18 | 2265 | 628 |
| Milestones | 214 | 0% | 0% | 15-Dec-17 | 27-Nov-18 | 15-Dec-17 A | 20-Nov-18 | 0 | 0 |
| Project Management | 188 | 21.33% | 15% | 27-Feb-18 | 27-Nov-18 | 27-Feb-18 A | 20-Nov-18 | 425 | 63 |
| Equipment | 176 | 54.33% | 26.32% | 26-Feb-18 | 26-Oct-18 | 26-Feb-18 A | 08-Nov-18 | 1840 | 566 |
| Final Documentation | 21 | 0% | 0% | 29-Oct-18 | 27-Nov-18 | 22-Oct-18 | 20-Nov-18 | 0 | 0 |
| CBM TH OQ | 124 | 100% | 100% | 08-Jan-18 | 30-Apr-18 | 23-Oct-17 A | 11-May-18 | 119 | 93 |
| SRIT | 124 | 100% | 100% | 08-Jan-18 | 30-Apr-18 | 23-Oct-17 A | 11-May-18 | 119 | 93 |
| Customer Provided Item (CPI) | 2 | 0% | 0% | 15-Jan-18 | 15-Jan-18 | 13-Feb-18 A | 14-Feb-18 | 0 | 0 |
| CBM HPTC OS | 133 | 99.03% | 100% | 27-Oct-17 | 15-May-18 | 27-Oct-17 A | 11-May-18 | 110 | 120 |
| SRIT | 133 | 99.03% | 100% | 27-Oct-17 | 15-May-18 | 27-Oct-17 A | 11-May-18 | 110 | 120 |
| Customer Provided Item (CPI) | 0 | 0% | 0% | 02-Jan-18 | 02-Jan-18 | 12-Jan-18 A | 12-Jan-18 | 0 | 0 |
| CBM TH | 74 | 2.82% | 2.82% | 03-May-18 | 20-Aug-18 | 26-Apr-18 A | 20-Aug-18 | 80 | 2 |
| SRIT | 74 | 2.82% | 2.82% | 03-May-18 | 20-Aug-18 | 26-Apr-18 A | 20-Aug-18 | 80 | 2 |
| Customer Provided Item (CPI) | 50 | 0% | 0% | 25-May-18 | 03-Aug-18 | 26-Apr-18 A | 03-Aug-18 | 0 | 0 |
| CBM XT OL | 145 | 100% | 100% | 23-Oct-17 | 30-Apr-18 | 23-Oct-17 A | 08-Jun-18 | 505 | 320 |




Actual Work | Critical Remaining Work | Second Baseline
Primary Baseline | Remaining Work | Milestone

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TASK filter: All Activities



Multi-project plans

# Appendix D. Example of engineering resources workload distribution in multi- project environment

Engineering resources- workload Distribution

| Activity ID | Activity Name | Budgeted Units | Original Duration | Start | Finish | Remaining Units | October 2016 | | | | | November 2016 | | | | December 2016 | | | | January 2017 | | | | | February 2017 | | | | March 2017 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 03 | 10 | 17 | 24 | 31 | 07 | 14 | 21 | 28 | 05 | 12 | 19 | 26 | 02 | 09 | 16 | 23 | 30 | 06 | 13 | 20 | 27 | 06 | 13 | 20 | 27 |
| Analyst Engineer | | 4342 | 736 | 24-Aug-15 A | 07-Jun-17 | | 129 | 147 | 175 | 190 | 156 | 176 | 141 | 133 | 203 | 162 | 89 | 66 | 6 | 56 | 26 | 27 | 25 | 25 | 31 | 31 | 32 | 31 | 31 | 21 | 20 | 20 |
| MCS Engineer | | 205 | 927 | 13-Apr-15 A | 19-Jan-17 | | 3 | 3 | 2 | 1 | 1 | 16 | 30 | 25 | 21 | 20 | 23 | 24 | 10 | 6 | 10 | 8 | | | | | | | | | | |
| PCS Engineer | | 16 | 5 | 05-May-16 A | 19-Sep-16 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EPC Controller | | 9620 | 1219 | 02-Feb-15 A | 22-Jun-18 | | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 51 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 | 65 |
| XT Subsea Eng. | | 6702 | 1179 | 01-Jan-15 A | 22-Dec-17 | | 147 | 141 | 131 | 120 | 100 | 71 | 116 | 95 | 60 | 73 | 66 | 60 | 38 | 30 | 31 | 34 | 31 | 64 | 78 | 66 | 107 | 139 | 146 | 135 | 146 | 98 |
| SPS Engineer | | 0 | 490 | 04-Jul-16 A | 28-Sep-16 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MCS Project Controller | | 1603 | 750 | 04-Feb-15 A | 22-Jun-18 | | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 19 | 26 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| Project Engineering Manager | | 9 | 49 | 07-Nov-16 | 19-Jan-17 | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | |
| MCS Connections Engineer | | 126 | 268 | 01-Aug-16 A | 05-Jan-17 | | 0 | 0 | 0 | 0 | 0 | 17 | 21 | 17 | 15 | 8 | 18 | 23 | 4 | 4 | | | | | | | | | | | | |
| Interventions Manager | | 2677 | 947 | 01-Mar-16 A | 20-Jun-18 | | 64 | 64 | 58 | 39 | 34 | 36 | 31 | 31 | 31 | 31 | 31 | 31 | | 31 | 31 | 31 | 31 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| Project Coordinator | | 4144 | 814 | 30-Sep-15 A | 22-Sep-17 | | 61 | 68 | 74 | 74 | 68 | 71 | 55 | 55 | 54 | 51 | 49 | 41 | 41 | 52 | 64 | 72 | 80 | 94 | 94 | 99 | 72 | 62 | 59 | 59 | 56 | 55 |
| Project Planner | | 530 | 427 | 30-Sep-15 A | 17-Feb-17 | | 10 | 10 | 10 | 10 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 7 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | | | | | | |
| MCS Piping Engineer | | 9 | 88 | 01-Aug-16 A | 01-Dec-16 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | |
| EPC Project Management | | 16200 | 705 | 04-Feb-15 A | 22-Jun-18 | | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 56 | 74 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 |
| Technical Manager | | 700 | 688 | 15-Feb-15 A | 06-Oct-17 | | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 13 | 17 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| MCS Designer | | 54 | 30 | 04-Jul-16 A | 21-Sep-16 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Subsea Eng. Manager | | 7 | 91 | 07-Nov-16 | 20-Mar-17 | | | | | | | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | |
| Subsea Trees Planner | | 160 | 735 | 15-Feb-15 A | 03-May-17 | | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 7 | 9 | 11 | 11 | 5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Materials Engineer | | 5248 | 896 | 19-Oct-15 A | 22-Dec-17 | | 193 | 172 | 156 | 136 | 120 | 112 | 115 | 103 | 83 | 82 | 82 | 84 | 17 | 105 | 97 | 64 | 51 | 31 | 10 | 5 | 4 | 11 | 15 | 15 | 15 | 15 |
| Subsea Eng. | | 117 | 798 | 01-Sep-15 A | 06-Oct-17 | | 10 | 10 | 10 | 10 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mechanical Tic Engineer | | 9171 | 885 | 04-Jan-16 A | 07-Feb-18 | | 383 | 342 | 350 | 317 | 320 | 229 | 231 | 233 | 243 | 317 | 315 | 298 | 131 | 286 | 295 | 226 | 253 | 291 | 269 | 262 | 206 | 146 | 151 | 121 | 96 | 94 |
| Mechanical Tic Engineer 1 | | 8913 | 479 | 14-Mar-16 A | 07-Feb-18 | | 368 | 327 | 335 | 302 | 306 | 220 | 221 | 224 | 234 | 307 | 306 | 289 | 122 | 277 | 286 | 217 | 244 | 262 | 260 | 253 | 197 | 137 | 142 | 116 | 96 | 94 |
| Tic Support | | 552 | 116 | 03-Oct-16 | 14-Mar-17 | | 22 | 22 | 22 | 23 | 23 | 23 | 23 | 24 | 24 | 24 | 24 | 23 | 18 | 23 | 23 | 25 | 29 | 29 | 29 | 23 | 23 | 23 | 23 | 9 | | |
| Maintenance Procedures | | 1660 | 116 | 26-Sep-16 | 07-Mar-17 | | 64 | 64 | 64 | 105 | 104 | 85 | 85 | 85 | 85 | 74 | 67 | 67 | | 67 | 67 | 67 | 96 | 102 | 99 | 84 | 43 | 22 | 9 | | | |
| SCM and CBM | | 45 | 15 | 03-Oct-16 | 21-Oct-16 | | 15 | 15 | 15 | | | | | | | | | | | | | | | | | | | | | | | |
| Corrib Flexible Connections | | 30 | 40 | 13-Jun-16 A | 05-Oct-16 | | 6 | | | | | | | | | | | | | | | | | | | | | | | | | |
| HCCS Gas Import Connections | | 30 | 40 | 20-Apr-17 | 21-Jun-17 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WI FSE Support | | 50 | 98 | 19-Jun-16 A | 31-Oct-16 | | 3 | 3 | 3 | 3 | 1 | | | | | | | | | | | | | | | | | | | | | |
| Tie in Equipment | | 2702 | 300 | 29-Nov-16 | 07-Feb-18 | | | | | | | | | | 46 | 93 | 100 | 82 | 65 | 96 | 101 | 78 | 84 | 116 | 107 | 124 | 109 | 70 | 89 | 87 | 76 | 72 |
| TBASLMP | | 150 | 110 | 03-Mar-17 | 15-Aug-17 | | | | | | | | | | | | | | | | | | | | | | | 1 | 7 | 7 | 7 | 7 |
| Flow Loop and Spool Distribution | | 2204 | 365 | 14-Mar-16 A | 29-Aug-17 | | 114 | 112 | 130 | 87 | 107 | 40 | 42 | 53 | 31 | 68 | 67 | 69 | | 43 | 47 | 34 | 31 | 26 | 21 | 18 | 19 | 18 | 11 | 11 | 11 | 11 |
| Pressure Cap | | 70 | 164 | 24-Oct-16 | 21-Jun-17 | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Connection Equipment on X-Tree | | 439 | 195 | 01-Aug-16 | 08-May-17 | | 63 | 28 | 19 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Corrib Connection Equipment | | 711 | 80 | 26-Sep-16 | 16-Jan-17 | | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 36 | 44 | 44 | 9 | | | | | | | | | | |
| Rental tool | | 260 | 43 | 26-Sep-16 | 23-Nov-16 | | 36 | 37 | 35 | 32 | 23 | 23 | 23 | 14 | | | | | | | | | | | | | | | | | | |
| Supply of Hardware | | 10 | 90 | 26-Sep-16 | 30-Jan-17 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | | | | | | | | |
| Mechanical Tic Engineer 2 | | 258 | 327 | 04-Jan-16 A | 14-Mar-17 | | 15 | 15 | 16 | 16 | 13 | 9 | 10 | 10 | 10 | 10 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 4 | | |
| Tic Support | | 214 | 117 | 03-Oct-16 | 14-Mar-17 | | 9 | 9 | 9 | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 4 | | |
| ONNE ACTIVITY PLAN | | 44 | 5 | 04-Jan-16 A | 03-Nov-16 | | 6 | 6 | 6 | 6 | 4 | | | | | | | | | | | | | | | | | | | | | |
| Service Manager | | 16 | 7 | 13-Jul-16 A | 26-Sep-16 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Service PCS Engineer | | 15796 | 1211 | 08-Jun-15 A | 22-Dec-17 | | 368 | 402 | 361 | 328 | 309 | 325 | 310 | 333 | 330 | 315 | 261 | 233 | 62 | 233 | 239 | 234 | 222 | 218 | 129 | 76 | 77 | 143 | 166 | 166 | 166 | 166 |
| Mechanical Engineer | | 9865 | 649 | 25-May-16 A | 22-Dec-17 | | 357 | 355 | 356 | 318 | 289 | 362 | 348 | 353 | 306 | 297 | 289 | 291 | 98 | 243 | 265 | 256 | 208 | 151 | 147 | 143 | 146 | 178 | 149 | 149 | 149 | 149 |
| Mechanical Engineer 1 | | 1491 | 249 | 25-May-16 A | 09-May-17 | | 31 | 31 | 31 | 31 | 31 | 30 | 30 | 30 | 30 | 30 | 30 | 18 | | 24 | 30 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| Tools Support | | 1361 | 209 | 22-Aug-16 A | 09-May-17 | | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 17 | | 23 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| Tools Support | | 1361 | 209 | 22-Aug-16 A | 09-May-17 | | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 17 | | 23 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| Tools - Offshore Support | | 1361 | 209 | 22-Aug-16 A | 09-May-17 | | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 17 | | 23 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| OFFSHORE SERVICES | | 110 | 128 | 25-May-16 A | 11-Jan-17 | | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | | 2 | 1 | | | | | | | | | | | |
| Mechanical Engineer 2 | | 706 | 250 | 05-Sep-16 A | 30-Jan-17 | | 50 | 45 | 42 | 43 | 43 | 63 | 77 | 64 | 65 | 66 | 61 | 62 | 47 | 41 | 41 | 41 | 30 | 0 | | | | | | | | |
| Tools Support | | 290 | 250 | 03-Oct-16 A | 30-Jan-17 | | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 0 | | | | | | | | |
| THROT, Test fixture | | 27 | 20 | 07-Nov-16 | 02-Dec-16 | | | | | | | 5 | 14 | 3 | 5 | | | | | | | | | | | | | | | | | |
| Main overhaul of SLC | | 39 | 37 | 05-Sep-16 A | 27-Oct-16 | | 6 | 6 | 3 | 2 | | | | | | | | | | | | | | | | | | | | | | |
| New Umbilical Clamps | | 28 | 15 | 07-Nov-16 | 25-Nov-16 | | | | | | | 8 | 9 | 10 | | | | | | | | | | | | | | | | | | |
| Surface Test Tree, Adapter | | 144 | 39 | 07-Nov-16 | 29-Dec-16 | | | | | | | 17 | 15 | 13 | 21 | 25 | 23 | 22 | 9 | | | | | | | | | | | | | |
| Inspection and check procedures for recertification | | 109 | 55 | 07-Nov-16 | 20-Jan-17 | | | | | | | 9 | 9 | 9 | 9 | 13 | 8 | 11 | 9 | 11 | 11 | 11 | | | | | | | | | | |
| Preservation, storage inspection | | 69 | 30 | 03-Oct-16 | 11-Nov-16 | | 13 | 9 | 9 | 12 | 13 | 13 | | | | | | | | | | | | | | | | | | | | |
| Mechanical Engineer 3 | | 1244 | 222 | 08-Aug- | | | 40 | 37 | 33 | 35 | 30 | 57 | 54 | 59 | 53 | 38 | 41 | 50 | 2 | 30 | 33 | 40 | 23 | 23 | 23 | 18 | 20 | 20 | 20 | 20 | 20 | 20 |
| PCS Opportunities | | 60 | 43 | 03-Oct-16 | 30-Nov-16 | | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 6 | | | | | | | | | | | | | | | | | |
| PCS Opportunities | | 60 | 43 | 03-Oct-16 | 30-Nov-16 | | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 6 | | | | | | | | | | | | | | | | | |
| Trapped pressure - mitigating actions | | 60 | 43 | 03-Oct-16 | 30-Nov-16 | | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 6 | | | | | | | | | | | | | | | | | |
| Tools Support | | 652 | 222 | 08-Aug-16 A | 10-May-17 | | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | | 20 | 22 | 23 | 23 | 23 | 23 | 18 | 20 | 20 | 20 | 20 | 20 | 20 |
| THROT, Test fixture | | 6 | 9 | 22-Nov-16 | 02-Dec-16 | | | | | | | | | 2 | 4 | | | | | | | | | | | | | | | | | |
| Feasibility study of THERT | | 99 | 49 | 07-Nov-16 | 19-Jan-17 | | | | | | | 12 | 13 | 11 | 9 | 6 | 13 | 16 | 0 | 8 | 6 | 4 | | | | | | | | | | |
| Main overhaul of SLC | | 34 | 41 | 01-Sep-16 A | 31-Oct-16 | | 4 | 6 | 3 | 1 | 0 | | | | | | | | | | | | | | | | | | | | | |

Engineering resources workload distribution in multi- project environment

# Appendix E. Example of Engineering disciplines workload distribution

ENG Disciplines- Workload Distribution

| Activity ID | Activity Name | Budgeted Units | Start | Finish | Remaining Units | | March 2018 | | | | April 2018 | | | | May 2018 | | | | | June 2018 | | | | July 2018 | | | | August 2018 | | | | | September 2018 | | | | October 2018 | | | | November 2018 | | | | | December 2018 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 6 | 05 | 12 | 19 | 26 | 02 | 09 | 16 | 23 | 30 | 07 | 14 | 21 | 28 | 04 | 11 | 18 | 25 | 02 | 09 | 16 | 23 | 30 | 06 | 13 | 20 | 27 | 03 | 10 | 17 | 24 | 01 | 08 | 15 | 22 | 29 | 05 | 12 | 19 | 26 | 03 | 10 | 17 | 24 |
| | Hymech Eng. | 713 | 08-Jan-18 A | 21-Aug-18 | | | | | | | | | | | 42 | 76 | 68 | 53 | 24 | 18 | 17 | 12 | 1 | 1 | 1 | 1 | 13 | 21 | 42 | 55 | 22 | | | | | | | | | | | | | | | | | | |
| | Hymech Engineer | 713 | 08-Jan-18 A | 21-Aug-18 | | | | | | | | | | | 42 | 76 | 68 | 53 | 24 | 18 | 17 | 12 | 1 | 1 | 1 | 1 | 13 | 21 | 42 | 55 | 22 | | | | | | | | | | | | | | | | | | |
| | Modification of XT | 40 | 03-Apr-18 A | 20-Jun-18 | | | | | | | | | | | 4 | 8 | 2 | 3 | 5 | 5 | 4 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | DIACS Modification | 673 | 08-Jan-18 A | 21-Aug-18 | | | | | | | | | | | 38 | 68 | 66 | 50 | 19 | 13 | 13 | 10 | 1 | 1 | 1 | 1 | 13 | 21 | 42 | 55 | 22 | | | | | | | | | | | | | | | | | | |
| | Mechanical Eng. | 4806 | 15-May-15 A | 17-Apr-19 | | | | | | | | 20 | | 51 | 213 | 137 | 125 | 117 | 148 | 202 | 185 | 178 | 133 | 102 | 91 | 66 | 80 | 66 | 92 | 74 | 50 | 50 | 48 | 21 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 7 |
| | Mechanical Engineer | 2617 | 15-May-15 A | 12-Sep-18 | | | | | | | | | | 51 | 147 | 39 | 46 | 62 | 81 | 139 | 113 | 97 | 82 | 85 | 75 | 50 | 64 | 49 | 29 | 22 | 22 | 22 | 20 | 1 | | | | | | | | | | | | | | | |
| | UPDATE PARTS | 474 | 15-May-15 A | 15-Jan-18 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Re-Configure Flexible Flowline | 1882 | 18-Jan-18 A | 12-Sep-18 | | | | | | | | | | 51 | 132 | 30 | 40 | 60 | 75 | 133 | 107 | 91 | 76 | 80 | 69 | 44 | 58 | 47 | 29 | 22 | 22 | 22 | 20 | 1 | | | | | | | | | | | | | | | |
| | Rep. After CBM | 60 | 01-Feb-18 A | 31-Jul-18 | | | | | | | | | | | 1 | 2 | 2 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 2 | | | | | | | | | | | | | | | | | | | | | |
| | CBM /SKACBP | 54 | 05-Feb-18 A | 18-May-18 | | | | | | | | | | | 7 | 4 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | DIACS Modification | 15 | 14-Feb-18 A | 07-May-18 | | | | | | | | | | | 8 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Creation of repair part numbers for rental tools | 132 | 08-Dec-17 A | 16-Feb-18 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Mechanical XT/Tools Engineer | 1448 | 02-Oct-17 A | 28-Dec-18 | | | | | | | | | | | 48 | 78 | 64 | 54 | 66 | 61 | 71 | 80 | 50 | 15 | 15 | 15 | 15 | 15 | 30 | 37 | 26 | 26 | 26 | 19 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 6 |
| | Engineering T&XT Support | 738 | 03-Jan-18 A | 28-Dec-18 | | | | | | | | | | | 6 | 12 | 12 | 12 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 6 |
| | XT update | 67 | 06-Aug-18 | 11-Sep-18 | | | | | | | | | | | | | | | | | | | | | | | | | 15 | 14 | 11 | 11 | 11 | 4 | | | | | | | | | | | | | | | |
| | Refurb of XT OL | 25 | 16-Apr-18 A | 16-May-18 | | | | | | | | | | | 7 | 7 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Modification of XT | 589 | 02-Oct-17 A | 29-Jun-18 | | | | | | | | | | | 32 | 52 | 37 | 40 | 51 | 46 | 56 | 65 | 35 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | DIACS Modification | 7 | 11-May-18 | 23-May-18 | | | | | | | | | | | | 1 | 4 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Update of injection test stump | 15 | 03-May-18 | 18-May-18 | | | | | | | | | | | 3 | 6 | 6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | CBM TH | 8 | 13-Aug-18 | 17-Aug-18 | | | | | | | | | | | | | | | | | | | | | | | | | | 8 | | | | | | | | | | | | | | | | | | | |
| | Mechanical TIC Engineer | 741 | 07-Nov-16 A | 17-Apr-19 | | | | | | | | 20 | | | 17 | 20 | 15 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 33 | 15 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 |
| | Rental tool | 240 | 07-Nov-16 A | 22-Feb-18 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | LAKACH | 35 | 20-Dec-16 A | 08-Feb-18 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | SLMP-K | 20 | 12-Apr-18 | 13-Apr-18 | | | | | | | | 20 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | CBM / SKA CBP | 416 | 10-Nov-17 A | 17-Apr-19 | | | | | | | | | | | 8 | 15 | 15 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 33 | 15 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 |
| | DIACS Modification | 30 | 14-Feb-18 A | 07-May-18 | | | | | | | | | | | 9 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Analysis Eng. | 612 | 24-Aug-15 A | 14-Jun-18 | | | | | | | | | | 8 | 80 | 70 | 63 | 52 | 44 | 14 | 11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Analysis Engineer | 612 | 24-Aug-15 A | 14-Jun-18 | | | | | | | | | | 8 | 80 | 70 | 63 | 52 | 44 | 14 | 11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | UPDATE PARTS | 100 | 24-Aug-15 A | 03-Jan-18 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Re-Configure Flexible Flowline | 410 | 28-Mar-18 A | 14-Jun-18 | | | | | | | | | | 8 | 66 | 63 | 63 | 52 | 44 | 14 | 11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Modification of XT | 72 | 28-Feb-18 A | 07-May-18 | | | | | | | | | | | 5 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | DIACS Modification | 30 | 14-Feb-18 A | 07-May-18 | | | | | | | | | | | 9 | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Material Eng. | 314 | 19-Oct-15 A | 02-Aug-18 | | | | | | | | | | | 1 | | | | 5 | 12 | 8 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | | | | | | | | | | | | | | | | | | | | | |
| | Material Engineer | 314 | 19-Oct-15 A | 02-Aug-18 | | | | | | | | | | | 1 | | | | 5 | 12 | 8 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | | | | | | | | | | | | | | | | | | | | | |
| | UPDATE PARTS | 81 | 19-Oct-15 A | 03-Jan-18 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Re-Configure Flexible Flowline | 75 | 04-Apr-18 A | 02-Aug-18 | | | | | | | | | | | 1 | | | | 5 | 12 | 8 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | | | | | | | | | | | | | | | | | | | | | |
| | Creation of repair part numbers for rental tools | 158 | 08-Dec-17 A | 16-Feb-18 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Engineering disciplines workload distribution