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Project Management in the Telecom Industry: an analysis of the current status and development of an optimized methodology

Relatore
Prof. Carlo Rafele

Candidato
Marta Vietti
Matr. S231385

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Anche se non è Acquasanta 2010, questa è comunque per te Nonno Carlo.

Abstract

The paper looks at the world of the Telecommunications and how its Vendors, who are the actors that develop and implement the network for the providers, deal with Project Management. In fact, being the industry in constant evolution, brought to seek for the development of an optimized project management approach, which could bring benefits to the success of the projects.

In the first section, after a brief introduction to the industry, all the theoretical aspects concerning Project Management are presented in order to make the reader familiar with the discipline, simplifying thus his understanding of the concepts once they are applied to the specific case of the Telecom industry.

In the second section, the paper focuses on the current application of Project Management in the case of one Vendor, describing the processes that bring to the success of the company, its organizational structure and roles, and the tools used to achieved the goals. By analyzing the current methodologies and tools, the papers seeks in fact to create the knowledge base necessary to identify the pain points.

Based on the evaluation of the current scenario, some critical issues are thus identified and analyzed to develop an optimized methodology that, if implemented, could improve the application of Project Management to the telecom projects, especially when looking at the direction in which the industry is going to.

1. Introduction to the Telecommunication industry

ICT, Information and Communication Technologies, refers to technologies that provide access to information through telecommunications, where Telecommunication is defined as "the transmission of information, as words, sounds, or images, usually over great distances, in the form of electromagnetic signals, as by telegraph, telephone, radio, or television" (dictionary). No other industry touches as many technology-related businesses such as the Telecommunications' one, in fact, it includes the areas of local and long-distance telephone service, including both wired and wireless, microwave communications, fiber optics, satellites, internet, artificial intelligence as well as various types of information distribution services such as radio, cable TVs systems, wearable devices, vehicles telematics. We are thus talking about a fast-paced sector that affects our every-day life aiming at making it more efficient and fulfilling.

Looking at the amount of technologies that define the Telecommunications world, it is already possible to understand how it involves different players. Comprising companies that produce the hardware, to those that produce the software, ending with the ones that deliver the service. All the elements are of extreme importance, in fact, the hardware is necessary to enable the communication, the services to run the switches and control the system, the software to make all work, and the A&I to discover new worlds.

On a Network transmission point of view we can identify four main components:

- Networking technologies: the physical infrastructure, composed by cables, transmission lines, network elements such as switches and software capabilities, and network applications such as storage networks.
- Operation Support Systems (OSSs): a series of components that are essential for the development, deployment and maintenance of a high-quality network by offering support in network monitoring, controlling, analyzing and managing. These components are applications and technologies that help the service providers offer their support services in an automated way.
- Methods and procedures to run the network: including all the processes involved in the installation, construction, maintenance and customer support.
- Content and applications: elements used to establish a direct relationship with the end-user by providing news, movies, etc., and dealing with the customer relationship management.

In such a competitive world, quality has a high importance as achieving the position of best certified network means high customer satisfaction and higher revenues; and in order to achieve the highest possible quality, different companies need to be involved. In fact, since the network is built in layers, including equipment for managing connections, software for data transferring and service, which is concerned with providing a particular functionality, to ensure the best possible quality, providers tend to specialize in one or two of these layers, requiring thus the cooperation of different companies. On this matter, this thesis will focus on the companies related to the production of the networking technologies to transmit the information, which means the ones responsible of the network development, improvement, expansion and maintenance. Network providers sell to service providers delivery platforms, including products and services, going from wireless networks, to fixed networks, to internet infrastructure, to carrier software and core networks, to enterprise networks, ending with Machine to Machine (M2M) connection management platform.

The industry itself has two points that make it very attractive: a big opportunity of revenue generating, and a continuous growth. The revenue opportunity is given by the fact that the infrastructure will always be needed and even if the telecom industry is facing each year more competition, coming from players that allow to stream content directly to consumers, the infrastructure providers do not lose their bargain power. The positive effect coming from the new players is also that the old service providers, in order not to lose their market, have to focus on constantly upgrading their network offering speed and throughput. Infrastructure investments are thus crucial for the industry since data traffic is increasing exponentially and consumers are asking for high-quality internet access to enjoy new internet services. However, looking at the European market, Europe has less high-speed broadband expansion compared to the other regions, ***Figure 1***. While North America and Asia have benefited from increased scale and growth opportunities, European operators are facing difficult years. The reason behind this slower growing pace is that the service providers faced years with less revenues and profitability, caused by the entry of private operators and applications that resulted in lower tariffs necessary to increase the market share keeping the number of subscribers high, making it more difficult to invest in the network expansion. However, as already stated, if the service providers will not invest, someone else will, which ensures profits for the companies that implement the network and develop the technologies. Moreover, ICT and digital communication are playing more and more a key role in the global economic development, which implies that poor connectivity can have negative impacts also on the productivity of a business and on the society. Governments are thus very interested in achieving a complete coverage and thus ready to start financing the Telecoms to expand the network.

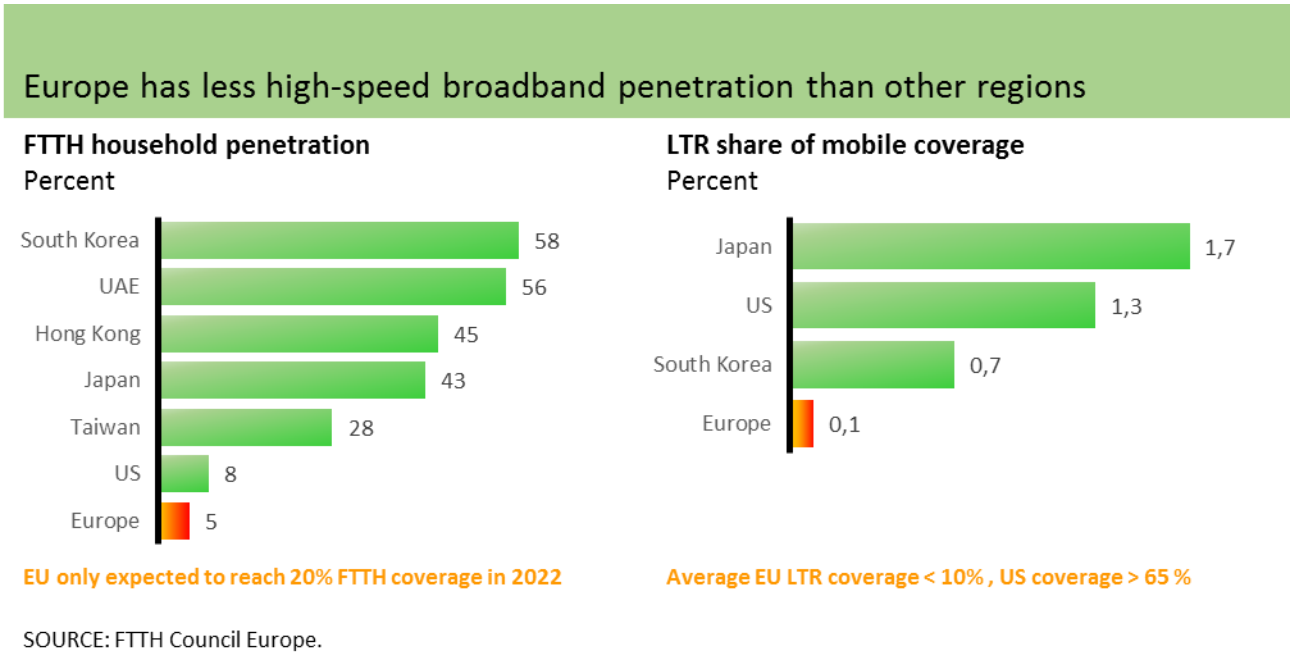


Figure 1 - High-speed broadband penetration

New technologies are what keep the business of these companies high as they drive changes in the cost models of the service providers and expand the business opportunities also with other industries. R&D is thus of extreme importance; only continuous innovation, aiming at upgrading the network infrastructure to satisfy the consumer and business demand, allows a position as a market leader. Data usage is continuously increasing, 5G trials are starting to be developed, researches on how to rationalize the networks and offer improved services through small cells, network densification and fiber infrastructure are being carried. This continuous search of improvement leaves space for new entrants, but works at the same time as a barrier. On one hand, in the past decade many new operators have entered the market forcing business strategy changes, compelling search for competitive advantages and a shorter time-to-market. On the other hand, this continuous search for new technologies to enable new services and offerings means that the size of the company matters. The business is expensive, and entrants need to be large enough to produce sufficient cash flow to cover the costs of expanding the network and improving the service, and to provide continuous maintenance. In the past years, operators have expanded their service portfolio, to meet this explosive demand, by differentiating and disrupting industries.

Looking at the market of the infrastructure providers, there are mainly four vendors that together produce more than half of the world's equipment, providing the most advanced wireless and fiber telecom equipment:

- Huawei: Huawei is a Chinese multinational networking and telecommunications equipment and services company that provides consulting services, hardware, software and post-service support. With a solid performance in market share, market share momentum and solution breadth, Huawei received the highest overall score for telecom vendor equipment and services becoming the world's largest vendor of telecom network infrastructure. The success of the company comes from mainly three factors: the governmental support, the end-to-end service offered together with complementary R&D activities, and the lower cost. In the past years, Huawei focused on increasing its market share, and thus the revenue, by keeping the prices low; the company's strategy is in fact to implement as many sites as possible, even if this means having less profits, by taking over as many projects as possible, which means that to succeed the company has to focus on a good coordination process that increases the speed and the efficiency. The reason behind this choice might be the potential of having an advantage in the race to the 5G, which is a good strategy considering that Huawei is one of the players with the highest R&D costs. Looking at the revenue, Huawei leads the market with an estimated revenue of $45 billion and is second as market share with 23.8% in the IT networks market. (telecomlead.com and statista.com).
- Ericsson: Ericsson, is a Swedish multinational whose offer includes services, software, hardware, and business support. It used to be the world's largest provider of telecom equipment and services, and even though it has stumbled over the past years its products are still seen as the gold standards of wireless infrastructure. The reason why Ericsson has been struggling is connected to expensive projects that did not generate as many profits as expected due to the high costs and the crises of the carriers that did not have much money to invest and therefore delayed the payments. For this reason, Ericsson is starting to focus more on a risk management strategy that reduces payment and failure risks. Based on "IT central station" its market share is of 35% and its revenue of $24.9 billion.
- Cisco: Cisco is an American multinational that develops hardware, telecommunications equipment and high-technology services and products. Cisco is the market leader of the Enterprise business, which will be presented later in the chapter, where it holds more than

50% of the market share (statista.com) leading to a loss of market share in the carrier network implementation. The strategy of the company is thus to focus on the software development to then expand to other business related to it.

- Nokia: Nokia is a Finnish company that used to be one of the market leaders, but is facing some drops in the past years due to less investments in the R&D and headcounts cuts after the acquisition of Alcatel. However, the company remains one of the biggest players with a revenue of $23.3 billion and a market share of 14.2%. Nokia has lost market share due to its inability to provide an end-to-end service; however, even though the contribution of the service is growing, exceeding in some cases the contribution of the manufacturing part, it is still of high importance to develop high-level equipment development, reason why the revenues of the company are still high.

Each company has its own strategy and each strategy hides a way of handling projects that goes from a strict and progressed way of handling projects, typical of a Waterfall methodology and a company such as Huawei, to more Agile procedures or cases where a high importance is given to the risk management, like the case of Ericsson. The study behind this thesis will thus start with an analysis of how the industry handles project management to find the pain points and develop a new methodology that improves the overall project experience and fit to the business' direction. In fact, in today's market, operators are under constant pressure to meet the needs of their customers by continuously improving their user experience. Which requires an acceleration in their network deployment plans in order to keep with the coverage and capacity demand. The limited time available to expand and redesign the networks, increasing the efficiency and speed, requires partners, that can both scale the deployment to meet the large and fast programs.

The new methodology will thus especially take into consideration the importance that agile, risk and change management have over the business, considering that the architecture of the network and the technologies used had some fundamental changes over the past years. Going from a world where PSTN, cable, and data networks were separately owned even if they coexisted and sometimes shared common technologies and facilities; to a world with a single common network. Integration that allows economies of scale and scope, growth of complementary services and differentiation. These providers are constantly looking to the next generation of mobile internet technology in order to remain into the big fours. As seen in the past trends, technology tends to evolve every ten years, starting with the first generation that supported only voice services that were seen to be as a luxury status symbol in the society, to the 2G (GSM, developed in the nineties) which was able to support more users and allowed text messages, to the 3G, which supported higher speed internet as well as videos on mobile devices, ending with the 4G, that increased the efficiency by allowing a faster speed of accessing mobile date. The pace of change in the telecom industry is refusing to slow down, so what is the world looking at now? Of course, the 5G, which aims at providing connectivity over the airwaves, and the patents to underpin the future mobile connectivity; but also the improvement of the current network, as without up to date equipment all the progresses made are vain. According to the research by the Market Research Institute, it is estimated that by 2025 there will be 100 billion of connectors (5x more than 2015), between people, people and things and things to things, which will be possible only through a high-quality network connection. 5G is not a single technology, but it incorporates all the previous generations of mobile systems creating a multi-layered system that overlaps macro-cells, remote radio heads and low powered small cells to connect all the devices.

Since the control of the network is in the hands of the carrier, the industry works through projects to fulfill the requests of the customer. Moreover, looking at the technological advances made over the year, makes it natural to organize the company's strategy through projects. Change represents one of the main challenges, as these organizations are based on delivering unique projects for external customers for a set time period, meaning that, in order to be successful, projects must be managed and each with its own approaches. To this end, a portfolio of projects and one or more programs have to be carried out.

The success of an organization will be thus identified with three aspects:

- Right solution implementation that fulfills the deployment requests at the right time,
- Flexibility in adapting to different scenarios,
- Advanced technology to improve speed, quality and predictability of the results.

Projects in this field include: adding capabilities into an existing network, establishing a specialized business network, and establishing a temporary network. The first is related to customer demand increase, taking into consideration the challenge of having to offer an expansion without, or at least minimizing, the disruptions in the service. The explosion of data requires to expand and redesign existing network by replacing obsolete technology or by adding new more advanced technologies.

Specialized networks are private networks normally owned by an enterprise for its internal communication to meet special requirements on security or costs. An enterprise network is thus used to reduce the communication protocols, facilitating the interoperability between the devices and improving the internal and external data management. The service provided through these kind of projects allow to automate activities improving the business operations and the employees communication and decision-making. In its daily work, an enterprise needs in fact ICT support to manage most of the processes along the value chain (supplier management, order management, production management, warehouse management, etc.); to support applications such as daily emails, cloud storages and knowledge sharing; and to allow interworking between regions and enterprise data centers. This type of projects is very common especially for the automotive industry to manage the exchange of information between the suppliers and the car manufacturers.

Temporary networks are built for major events to cover a huge amount of data being exchanged. The difficulty behind these projects lays in the end-date that must be met, regarding the costs, to provide a robust and reliable speed and throughput within the event.

The companies in this industry will tend to work thus with different clients, that can be mainly identified with: carriers, which include both the network expansion and the temporary sites, and enterprises. Of course, each type of project will require a different types of project management therefore, before analyzing the specific case of the telecommunications industry, it is appropriate to revise the concepts that lay behind the project management.

2. Project Management

Everything that an organization does can be organized either as a project or as a process. But while a process is something that happens continually and is associated to a low risk, a project happens once and has a higher uncertainty. A project is defined by the PMI®, *Project Management Institute*, as "a temporary endeavor undertaken to create a unique product, service, or result", underlying the main characteristics that describe it:

- Temporary: which means that a project is discrete and has a beginning and an end; it does not mean that a project must have a short duration, but that it must have a clear end, whether by goals achieved, or impossibility to meet, or by no longer necessity of it. The limited duration implies that scope and resources will be defined.
- Unique: even if the outcome can have some repetitive elements, the combination of location, design, circumstances, situations and stakeholders must be unique. The uniqueness is influenced by the constraints and specific set of operations that lead to the goal.

A more modern definition, describes a project as s "unique set of activities with a beginning and an end, undertaken to meet some established goals, objectives and deliverables within defined constraints of scope, quality, time, cost and stakeholder or customer satisfaction", underlying its boundaries determined by scope, quality, time and cost as well as the limitations given by the goals. One point that is very important, especially in the Telecom industry, where success is defined by the customers, is the fact that customer satisfaction was added to the definition.

Moreover, looking at other literature, such as the one from the Harvard Business School and the publications of Russell D. Archibald, one of the main representatives of Project Management, three more characteristics can be identified. A project is complex, as it includes different business areas requiring thus a strong coordination; has a progressive elaboration, the outcome is therefore produced through increments, which means that as time passes, the team learns more about the project and is thus able to manage it with a greater level of detail; and bound by constraints. In fact, in order to achieve the objectives, three main constraints, known as the *iron triangle* (***Figure 2***), have to be met: time, scope and cost.

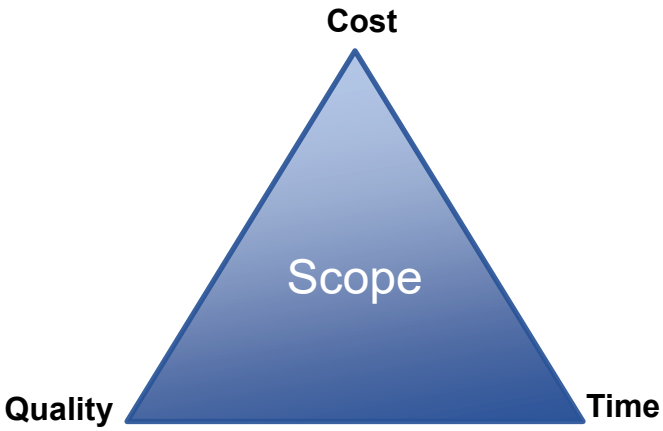


Figure 2 - The Iron Triangle

Under the main constraints we can identify many more of them as when we talk about costs, we are considering also the resources allocation, when about the scope, we can identify also quality and customer satisfaction, and as a "shared" constraint we can identify the risk.

- Cost is the budget approved for the project, including all the expenses needed to deliver.
- Scope is what the project is trying to achieve, including the processes used to produce the outcome.
- Time is the time to complete the project and since it reflects the missed deadlines and incomplete deliverables it is used to oversight the project. A proper project will have a defined schedule with a sequence and the duration and the resources allocated estimated for each task.
- Quality is a combination of standards and criteria that the project must meet.
- Risks are the potential events that will have a negative impact on the project.
- Resources are the people, equipment, facilities, or funds necessary to complete the project activities.

A project without constraints would have an 100% probability of success, however in the real world these must be balanced, and, considering that they are related in a way that if one changes at least one other factor is affected and that there are unknown elements that create risks, a good programming and controlling, together with managerial capabilities will be necessary to reduce the uncertainty of success.

In this context, Project Management, defined by the PMI as "the art of directing and coordinating human and material resources throughout the life of a project by using modern management techniques to achieve predetermined objectives of scope, cost, time, quality and participation satisfaction" / "the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements" was developed. Managing a project involves several actions, including the identification of the requirements and goals, the specification of the balance between the constraints and adaption of plans and approaches in order to satisfy all the stakeholders. The primary challenge of project management is thus to complete activities to achieve all the project goals by fulfilling also the scope, time, quality, and cost constraints. Where activities are defined as "a distinct, scheduled portion of work performed during the course of a project" (PMI).

This definition, recognizes how Project Management brings several capabilities and tools, as well as different stakeholders that handle different phases of the project, recognizing the critical need to communicate and coordinate across departments. Which can be translated into one sequence: "plan before doing. Which can be a tricky application if we look at planning as "doing the right thing", so maximizing the effectiveness, while doing is "doing things right", which leads to a focus on fulfilling the requirements without overpassing the boundaries and maximizing the efficiency. Through Project Management it is thus possible to reduce the risks by having a plan that deals with all the contingencies.

Looking at the nature of the projects, they involve innovation and change, which means that the management should not focus only on hard skills, such as models, algorithms or calculations, but also on soft skills.

To fully describe the scope of Project Management, the PMBOK® (*Project Management Body of Knowledge*), reference book at an international level describing project management practices, defines the five areas of expertise required to successfully manage a project:

- Understanding the project environment: setting the context of the project is of extreme importance, especially if we consider that by project environment both external and internal conditions are meant. Where the external environment involves cultural, social, political and physical impacts. While the internal includes the scope, quality, time and cost constraints.
- The Project Management Body of Knowledge: made of five Project Management process groups, that are build up to the project lifecycle, and ten knowledge areas.
- Application area knowledge, standards, and regulations: Application areas are made up of categories of project that have common elements, defined in terms of functional departments, technical elements, management specialization and industry group, and are characterized by standards and regulations from the ISO, International Organization for Standardization, which work as a support for the projects.
- General management knowledge and skills: foundation of skills (such as financial management, sales and marketing, manufacturing and distribution, logistics and supply chain, strategic planning, etc.) that are essential for the project manager.
- Interpersonal skills: personal skills, such as effective communication, leadership, motivation, conflict management and problem solving, that support the project manager on successfully achieving his tasks.

The PMBOK, ***Figure 3***, identifies ten knowledge areas, including five primary elements: the management of the scope, time and costs (already introduced as primary constraints) together with quality and risk management. And four secondary functions: human resources, communication, procurement and integration.

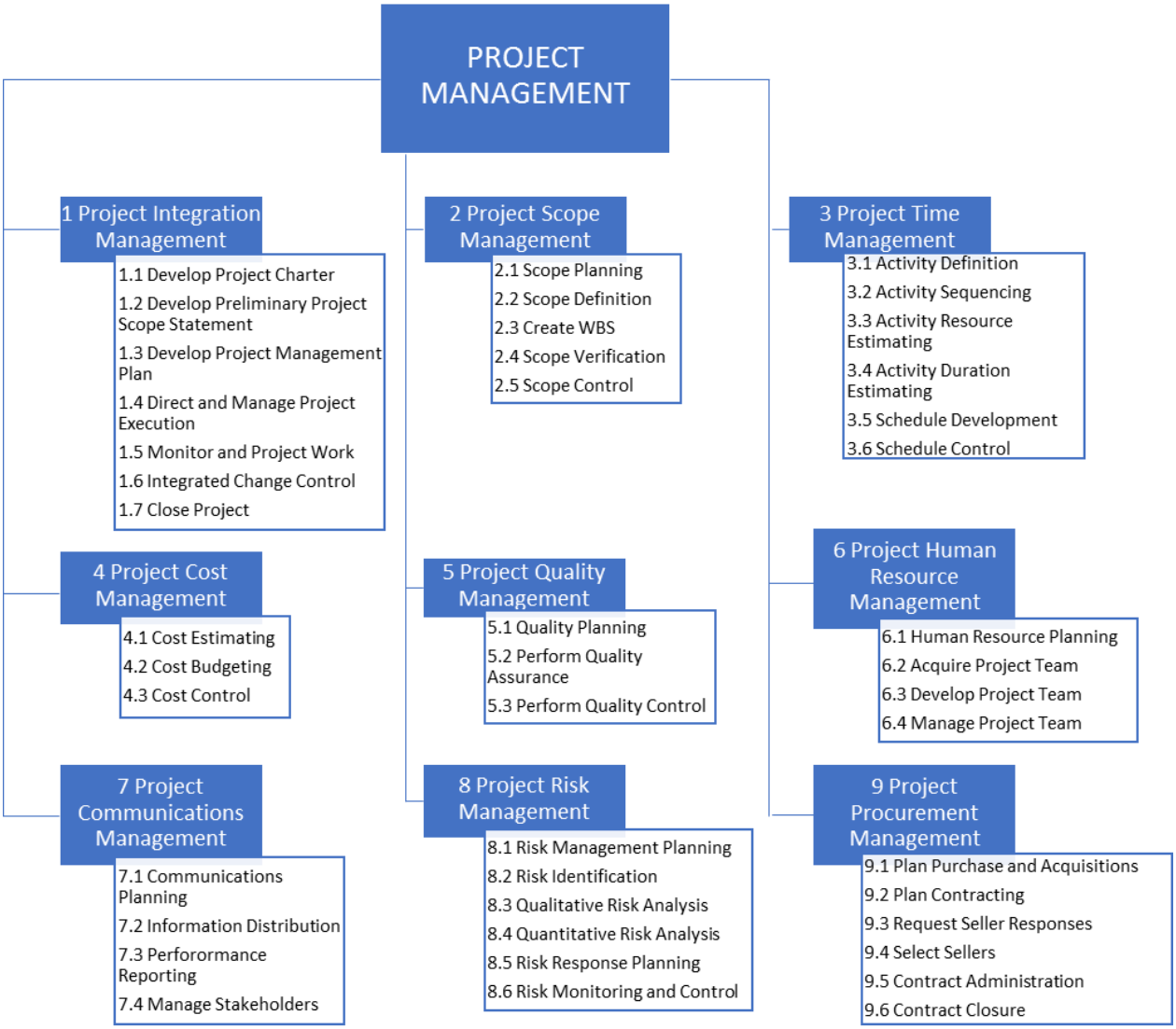


Figure 3 - Overview of Project Management Knowledge Areas (PMBOK)

Finding the correct balance of these factors is extremely important for the success of the project, for this reason, all the knowledge areas are then grouped into five project processes, that identify also the major factors that influence the project success: project initiation, project planning, project execution, project monitoring and controlling and project closure. Whatever is the nature of the project, the Project Management techniques are applied during the whole life-cycle, which can be seen under two different perspectives; on one side as a series of phases, the second as a cycle mechanism, where in each phase all the activities are considered.

If we look at the project classification by Max Wideman, the industry analyzed produces an output that fits both the "Engineering&Construction" and the "New Product" area, ***Figure 4***. In fact, the output is tangible but, depending on the elements considered it can be both handcrafted or intellectual. This categorization will then influence the way projects are handled, as on one side resources and costs can be predicted, on the other the high-level of technology involved will require agility and risk consideration.

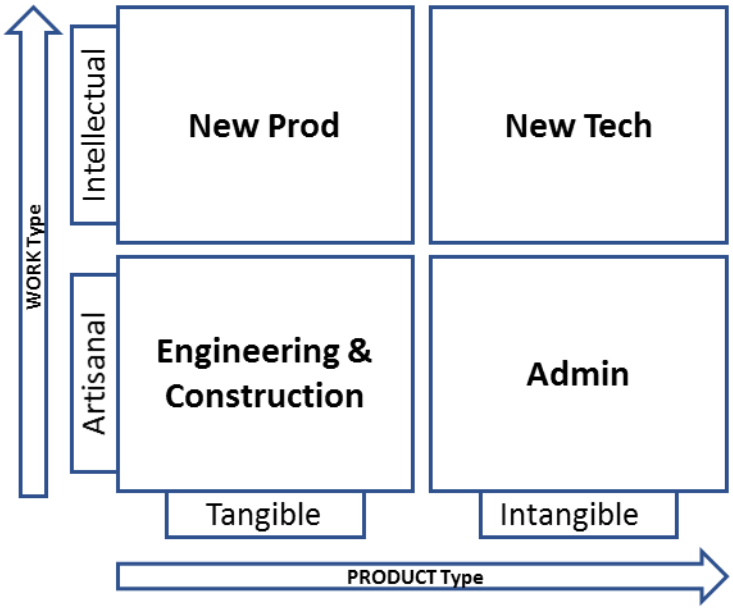


Figure 4 - Project Classification by Max Wideman

Especially in an industry technologically advanced as the one of the Telecommunications, where companies do not focus on only one business, or one project, but have a high scope with lots of technologies involved which bring to multi-disciplinary systems, re-planning is frequent. Therefore, in order to harmonize the production and to create higher profits, Project Management is brought to a strategic level with the introduction of Portfolios and Programs.

2.1. Portfolio, Program, Project

In the last decades, three levels were identified:

- Project Management, which deals at an operative level to produce deliverables;
- Program Management, which aims at coordinating projects through programs, by correctly allocating resources, in order to deliver benefits and capabilities;
- Portfolio Management, which works at a strategic level to coordinate the programs and define the goals of the projects.

Project management aims at achieving specific deliverables that support specific organizational objectives, Program Management focuses on reaching a common goal within projects, Portfolio management works as a bridge between program and project management and the organizational strategy. An element that defines the Program distinguishing it from the Portfolio is the common goal that its projects identify, bringing a strategic importance to the company. While if the activities and projects have only a shared know-how, technology or budget then they will be managed through a Portfolio.

It is important to underline that a deliverable identifies each unique and tangible product, service, element, or in general result that is produced at the conclusion of a project phase. The PMI defines it as "Any unique and verifiable *product*, *result*, or capability to perform a *service* that must be produced to complete a process, phase, or project".

2.1.1 Program Management

As projects increased their sizes and companies became more and more project-centric, increasing the number of projects that they coordinate at the same time, organizations had to find a new way to manage them to achieve the most benefit possible. In fact, the increase in the number of stakeholders, each with different requests, pushed to the development of new Project Management methodologies that aimed at collectively managing different projects to satisfy all the stakeholders. Organizations initiate thus programs to balance the degree of change, stakeholder expectations, requirements, resources, and timing conflicts across the projects.

The main element that contributed to the growth of the complexity was the necessity of dealing with activities that were functionally connected but that did not have a strong enough bond to justify their management through a project. For example, those activities that influence several projects, without being included in the Work Breakdown Structure (Cap X) of a single project, such as the R&D. However, the management through programs is not only limited to this case, but has a broader scope, that includes managing huge projects, such as the construction of buildings, that involve different stakeholders; and organizing activities that aim at an organizational change or strategic evolution.

The PMBOK defines a Program as "A group of related *projects, subprojects, and program activities,* managed in a coordinated way to obtain benefits not available from managing them individually". The program is used in order to take the maximum collective benefit from a group of interrelated projects that share a common goal, often of strategic importance, even though each project creates its unique result. If the projects are related only through a common funding, technology, resources or stakeholder, and do not share a common benefit delivery then they will be managed with a portfolio and not with a program.

Benefits are an outcome of actions, behaviors and products that produces value to the recipient, intended as the sponsoring organization and the stakeholders, and in this particular case they are meant to support the organization's strategic goals and objectives. Some programs deliver a benefit only when all the projects that make it are completed (e.g. construction sites such to build bridges), others may produce incremental benefits that start to produce a return on investment (ROI) before the whole program is completed, but in any case, the effort is not complete until the program has completed all the projects necessary for business improvement. In this second case, a program roadmap will be particularly important, since it allows the chronological representation of the program direction, establishing the relationship between the program and the projects through specific milestones. The roadmap also summarizes key end-point objectives, challenge, and risks.

In a program, projects are managed separately but, at some stage, they are joined and managed as a single entity to share common activities, skills or tools that allow to achieve strategic objectives and benefits, enhancing the success of the program as a whole. Through Program Management, a number of projects are thus harmonized in order to create value for the program sponsor in the short term and change the organization in the long term. In fact, Program management serves as a

bridge between value creation and business strategy allowing to deliver at the same time business value to the sponsoring organization and strategic value to the stakeholders.

Program management is "the application of knowledge, skills, tools, and techniques to a program to meet the program requirements and obtain benefits and control not available by managing projects individually". Through it, it is thus possible to achieve the common goal optimizing the cost, effort and resources, enabling a planning, controlling and delivery that aims at increasing the strategic benefits. In a broader sense, programs include work elements, identified with the projects, but also other auxiliary activities, such as trainings and maintenance activities, that are intended to manage the program in the best possible way by coordinating the activities.

Program management is identified by five interrelated and interdependent performance domains that uniquely characterize and differentiate the activities that will interact throughout the course of the program. "Program Strategy Alignment" that aims at identifying the opportunities for the organization's strategy coming from the program, "Program Benefits Management", which defines the benefits produced by the program and how to manage and enhance them, "Program Stakeholder Engagement" that serves as a collection of the stakeholders needs and expectations, "Program Governance", which establishes how to support the policies and practices, and "Program Lifecyle Management" that includes all the activities related to the other domains necessary to manage the program, ***Figure 5***.

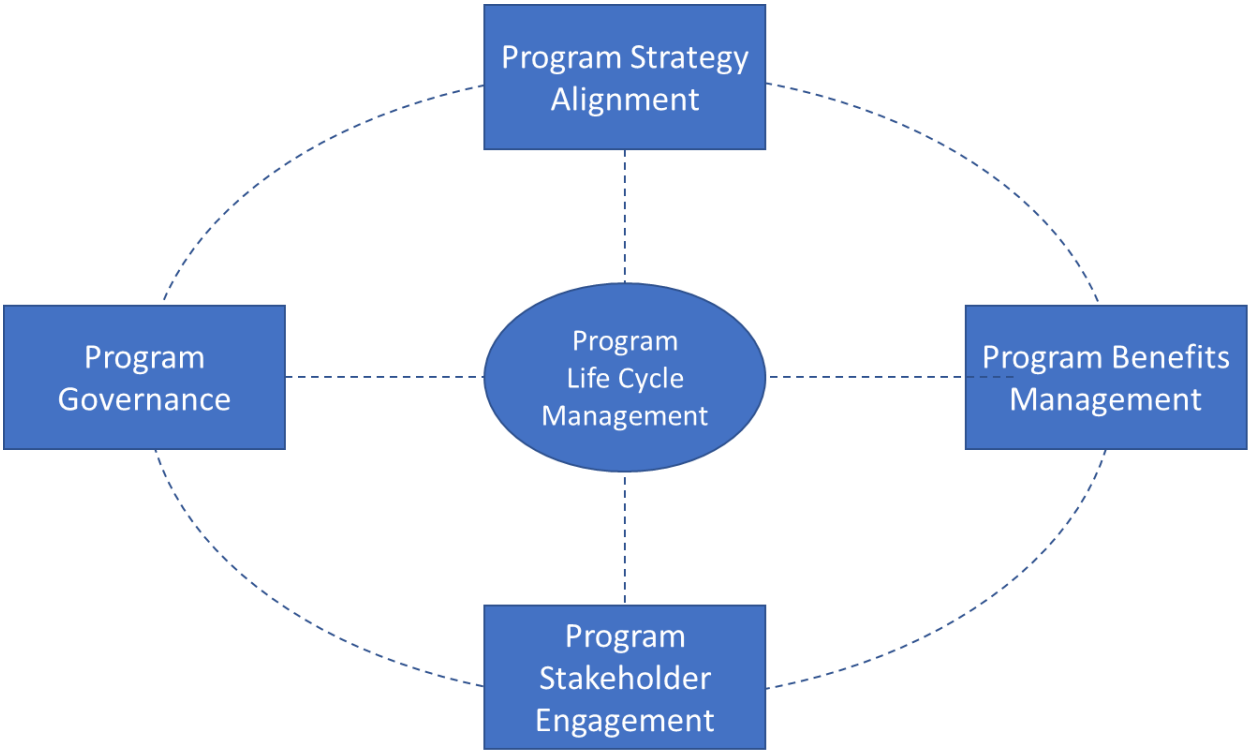


Figure 5 - Performance domains of Program Management

The lifecycle phases, similarly to the project lifecycle but with a different content and scope, include:

- Program definition, where the outcomes are defined identifying the common goal that the projects have and that fulfills the strategic objectives. In this phase also the roles, responsibilities and resources are allocated by creating an overall schedule that will include the risks and budget definition. Once the plan has been defined, the structure and the policies of the program are also defined.
- Program Benefits Delivery, iterative phase where the components of the program are planned, integrated with the existing structure, managed and monitored. The more often these activities are done, the more effective the program will be.
- Program Closure, where the results of the program, both on an economic and on a managing point of view (including brand expansion, know-how acquired) are passed to the stakeholders as lessons learned and goals achieved.

In the literature four types of programs are presented: Strategic, Key Operational, High Potential, and Support. "Strategic" programs, are about delivering assets unique to the organization and linked to the area where it competes, these programs are thus driven by innovation and change. "Key Operational" programs deliver assets that affect the daily-life of an organization, like improving the effectiveness of the business. "High Potential" programs deliver uncertain outcomes and are used to test ideas for the future, creating opportunities for business changes (e.g. R&D projects). "Support" programs provide assets that are valuable but not essential for the organization, for example the ones connected to efficiency gains.

Sometimes projects are selected for competitive necessity, to face expansions or not to lose market share; but most often, the selection of investment opportunities arises from the need of giving the highest return to the financial investment. For this reason, program managers must select and rank similar projects that are under their program, to understand which ones will bring the maximum advantages and returns. Different methods can be used to identify the best projects to carry on within the program; these can be both of a qualitative and quantitative type. Qualitative methods include the SWOT analysis, as well as multiple attribute techniques, which aim at selecting the preferred solution based on attributes defined by the PMO. Quantitative methods, on the other hand, are based on the performance index (PI), which gives a weight to each performance indicator, or the net present value (NPV), which analyzes the profitability of the project.

The responsible person of Program Management is the Program Manager whose goal is to ensure that the program works properly and that the results are correctly integrated with the business strategy by determining the optimal approach for managing the components. Therefore, the Program Manager works within the domains, supporting and guiding the Project Managers, to define the optimal way of managing the program depending on the phase being handled (for example, the stakeholders will be engaged in the beginning and end of the program, where the financial problems and results are discussed, while the governance and the project managers will be included in the central phases, where the outcome is developed).

Activities associated to the role of the Program Manager include:

- Leading and coordinating the activities within the program solving the conflicts that may arise.
- Communicating and reporting to stakeholders the evolution and the milestones achieved.
- Responding to risks.

- Aligning program efforts and goals with the long-term strategy of the organization
- Resolving scope, cost, schedule, quality, and risk impacts.
- Defining a governance structure for the entire program.
- Tailoring program management activities to effectively address cultural, political, and environmental differences in programs.

Of course the impact of the Program manager depends on the type of Program being handled and on the nature of the projects that make it up. Programs are in fact divided, based on their impact on the organization, into three categories: the "rectangular", when the projects have to be coordinated only in some specific critical common elements the program is simple and serves only as a coordination of the execution; the "pyramid", where the projects have the same strategic goal and the program will thus impact also the decisions to achieve the common goal; the "hourglass", where the Program Manager has to coordinate all the stakeholders to consider all the divergent interests in his decision-making processes.

2.1.2 Portfolio Management

A major development in Project Management has been the recognition that projects must be managed on a portfolio basis in most large organizations. In fact, with the growth of importance of projects for the organizations, the executives are no longer interested only on when a project will finish or how much it will cost, but especially on if their mix of projects will maximize the growth of the company or is optimized to achieve their objectives. The problem in this case cannot be addressed neither with Project Management, nor with Program management, but a new entity has to be introduced: the Portfolio.

The PMBOK defines a Portfolio as "A collection of programs, projects, or operations that are managed as a group to achieve strategic objectives". The key word is "strategic objectives", in fact elements within the portfolio are all related to the strategic goals through the Portfolio itself. The elements of the Portfolio may be independent in terms of objective, but they will be related to the same strategic goal; and in order to ensure that the conflicting demands are balanced and that the longevity and success of the organization is kept, Portfolio management is used. A Portfolio, ***Figure 6***, is thus a collection of Programs and operational projects that works as a bridge between the organizational strategies and the programs, projects and operations. Through the Portfolio the organizational strategy is reflected to the projects and programs ensuring that the organization's intent and direction is kept and that the resources are allocated based on the priorities.

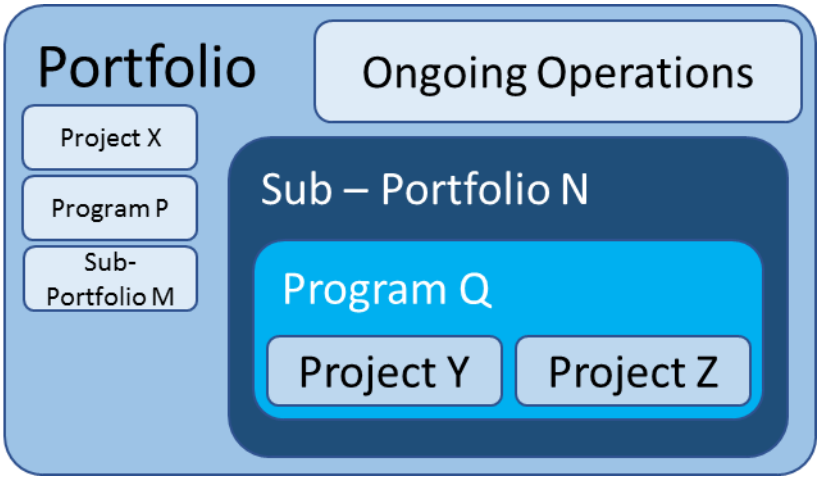


Figure 6 - Project Portfolio

The benefit in this case is not connected to a specific output, but to the entire value of the business. In fact, the success of the portfolio of programs, projects and operations is linked both to successful realization of the activities, but also to how big is the gap between the achievements and the organization's mission (orientation to market, competitive advantage, probability of success.), aiming at selecting the projects and programs that fit best the organizational strategy and allocating the resources in the best way to achieve it.

Portfolio Management is "the coordinated management of one or more portfolios to achieve organizational strategies and objectives". Portfolio Management is a methodology for analyzing, selecting and managing a group of current or proposed projects based on several characteristics while considering also constraints imposed by the management or by external factors. The three main requirements that the Portfolio looks for in projects are: its capacity to maximize the value for the company, the impact that the new project will have on the portfolio, if the final portfolio will still be strategically aligned and if it will truly reflect the business' strategy.

Where the goal can be identified on the alignment between the organizational strategy and the objectives of the programs, projects and operations. In fact, by managing programs and projects at the same time, the portfolio management is able to provide an efficient allocation of all types of resources, human, technological and financial.

A successful Portfolio management will coordinate the internal resources of the organization. In fact, on one side there is the senior management, which decides the strategy, on the other there are operative functions (such as the project or program managers) that have to implement the strategy to achieve their own goal. A top-down organization won't take into consideration the needs of the operative functions, while a bottom-up organization will lose sight of the core business value of the organization. Through the portfolio, the flow of information goes on both directions, allowing an optimal alignment and an efficient engagement of all the parties involved, going from the internal and external stakeholders, to the human resources.

Once a company has defined its organization's strategy to align the operations with it, the portfolio management is implement through two phases. In the first phase, first the projects are identified and aligned based on organizational priorities by an evaluation of the each potential project's values, benefits and risks; then they are organized based on similar properties to facilitate the distribution of the budget and to have a balanced mix inside each portfolio; once the portfolio's

mix is determined the projects that are not aligned with the organizational strategy are eliminated and the rest are evaluated by assigning a priority to each project based on its importance; if some risk budget is left, the remaining projects are balanced paying attention not to overcome risks estimated that the company can handle. In these steps, it is important to cope with resources challenges; in fact, even though there could be a high number of valid projects, resources are limited and in order to be successful the same people cannot work in many high priority projects. Once the final selections are made and the sequence of the projects is established the process moves to phase two, which is based on the traditional project sequence of initiation, execution, and control. The initiation starts with the authorization from the stakeholders and the creation of a Project Charter, the execution defines the budget and resources allocation based on the prioritization and on the reviews of the previous months, while the controlling phase aims at verifying that the project keeps being aligned with the strategic values and that it is not over-exceeding the budget and duration projections.

One of the most important steps is the prioritization of the projects. This can happen either through a Single-Criterion Prioritization model or with a Multiple-Criteria Weighted Ranking. The first, does a pair-wise comparison of different projects by having the list of projects both on the rows and on the columns and assigning a value to the interception based on which project has a higher priority based on that criteria (a value of 0 is associated to the project on the row, 1 to the project on the column). Once the whole table is completed, through the sum of the scores of each column, it is possible to understand which project has a higher priority for that particular criteria. The second, evaluates the projects based on multiple criteria each with an own weight (total sum of the weights 1) that implies the importance of the criteria for the organization. For each criteria the projects are then ranked based on their score; the highest priority is assigned to the project with the lowest score.

The person responsible for the execution of the Portfolio Management is the Portfolio Manager who focuses on aligning the portfolio components and providing the appropriate options of action. The portfolio manager should establish criteria for governance actions, such as deciding when projects/programs should proceed, be terminated, or suspended prior to originally planned completion dates.

The activities performed by the Portfolio manager can be brought mainly to six:

- Alignment of the portfolio with the strategic objectives, which requires a deep understanding the organizational strategy to decide also if adding or deleting portfolio components. In fact, if a project does not follow the parameters of the Portfolio, or deviates from the organizational strategy, it may be excluded from the Portfolio.
- Making investment decisions by allocating correctly the financial resources owned by the company.
- Allocating human resources based on the priority of each program, project or operation. In fact, human resources are limited and must be allocated taking into consideration the requests of each program or project manager, based on the importance given to the project considered.
- Allocating equipment or material resources.
- Measuring the performance to obtain key performance indicators that, through feedback, provide an input for potential changes in the strategic direction of the organization. In fact, through assesses of the current state, it is possible to understand which processes are needed in the organization and what enablers and barriers were encountered throughout the

implementation. The most commons indexes used to evaluate the projects we find the Net Present Value, the Internal Rate of Return and the Return on Investments.
- Managing risks by monitoring how those impact the strategic plan and objectives.

2.1.3 Integration Project, Program and Portfolio

The relationship among portfolios, programs, and projects is such that a portfolio represents a mix of programs, projects and sub-portfolios brought together to align the work with the strategic objectives, by selecting the right projects, prioritizing and providing resources. Programs comprise projects that share common goals, controlling their interdependencies to realize the specific benefits. Projects are either within or outside a program and implement the activities necessary to achieve a specific scope.

In order to properly understand these concepts, it is important to recognize the similarities and differences that exist between them. In fact, even though portfolios, programs, and projects are aligned with the organizational strategy, they contribute to the value of the business in different ways leading to similarities and differences that create conflicts.

Portfolios are used to align the strategic objectives of its projects and programs by approving only the ones that support the business objectives, by controlling the level of risk of the portfolio and by allocating the resources. Through the portfolio it is thus possible to follow the progress of an organization and its strategic direction. Programs, on the other hand, are created to coordinate the efforts between projects, in an iterative and cyclical way, by tracking the contribution of each project and the progresses made and continuously aligning them to the desired goals. In this context, it is important that the Project Manager keeps his freedom from the Program Manager, who should have the role of tracking his performance in an overall point of view, without getting involved in the specific decisions within the project. In fact, the autonomy of the Project Manager is one of the elements of success for the projects. Program Management should aim at verifying the alignment of a project to the common benefit and the portfolio, without hardening the organizational structures with too many rules or procedures.

Project and Program Management have mainly three differences, regarding the scope of action:

- The project produces tangible, intangible and economical results that contribute to the overall benefit of the program, whereas programs have to identify the benefits and measure the progress made.
- When dealing with stakeholders, project managers looks at how to produce the output requested, while program managers focus on how to keep a long-lasting relationship by engaging the stakeholders since the first phases.
- The relationship with the governance is set by the program who assures that the rules as well as the procedures and policies are followed. In the meanwhile, through a program results must be reported to the portfolio level.

Figure 7, allow to visually introduce the relationship between Portfolios, Programs, Projects and Sub-Programs.

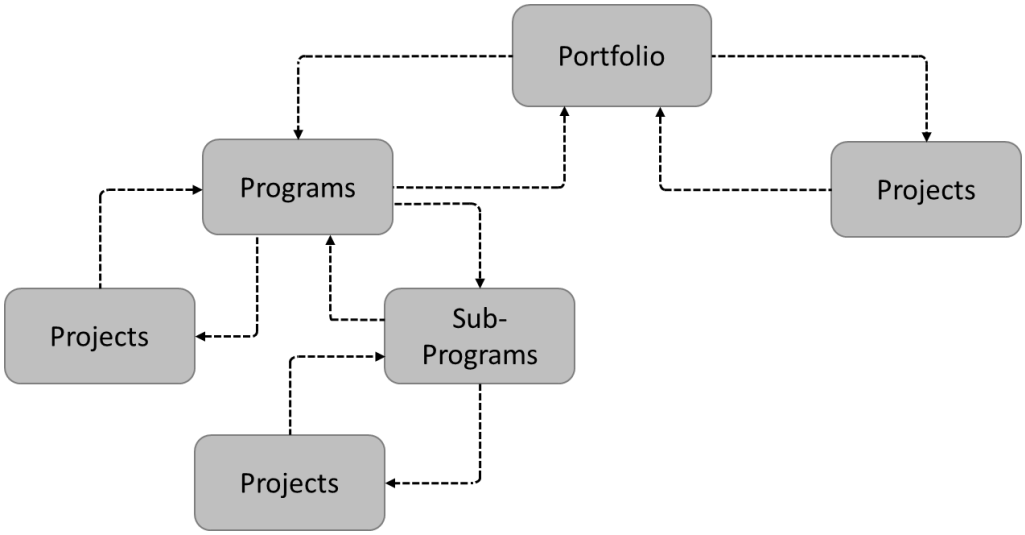


Figure 7 - Relationship between Portfolio, Programs, Sub-Programs, and Projects

As shown in the figure, the directions of the transmission of information is bi-directional and, depending on the phase of the project, there will be the predominance of one direction over the other. Top-Down streams refer to hierarchical decisions, while Bottom-Up streams transfer information coming from the monitoring phases, the progress checks and the reports of the projects. When making decisions, in order to achieve a correct balance between the top management requests and the operational needs of the specific functions, both streams should be considered.

The specific differences between projects, programs and portfolios across several dimensions within the organization are presented in ***Table 1***.

Table 1 - Comparative overview of Project, Program and Portfolio Management

Organizational Project Management			
	Projects	**Programs**	**Portfolios**
Scope	Projects have defined objectives. Scope is progressively elaborated throughout the project life cycle.	Programs have a larger scope and provide more significant benefits.	Portfolios have an organizational scope that changes with the strategic objectives of the organization.
Change	Project managers expect change and implement processes to keep change managed and controlled.	Program managers expect change from both inside and outside the program and are prepared to manage it.	Portfolio managers continuously monitor changes in the broader internal and external environment.
Planning	Project managers progressively elaborate high-level information into detailed plans throughout the project life cycle.	Program managers develop the overall program plan and create high-level plans to guide detailed planning at the component level.	Portfolio managers create and maintain necessary processes and communication relative to the aggregate portfolio.
Management	Project managers manage the project team to meet the project objectives.	Program managers manage the program staff and the project managers; they provide vision and overall leadership.	Portfolio managers may manage or coordinate portfolio management staff, or program and project staff that may have reporting responsibilities into the aggregate portfolio.
Success	Success is measured by product and project quality, timeliness, budget compliance, and degree of customer satisfaction.	Success is measured by the degree to which the program satisfies the needs and benefits for which it was undertaken.	Success is measured in terms of the aggregate investment performance and benefit realization of the portfolio.
Monitoring	Project managers monitor and control the work of producing the products, services, or results that the project was undertaken to produce.	Program managers monitor the progress of program components to ensure the overall goals, schedules, budget, and benefits of the program will be met.	Portfolio managers monitor strategic changes and aggregate resource allocation, performance results, and risk of the portfolio.

Having at the same time a Program and Portfolio Management allows thus to align the operative activities with the business strategy. However, it is important to find the right balance between these two entities and the projects. In fact, if the requirements, objectives, competencies are not well integrated and coordinated these tools will be useless and, internally, a sort of bullwhip effect will be generated, the inputs coming from other entities perceived as meager. While a correct mix, with a well-defined hierarchy of the roles and objectives that can be quantitatively and qualitatively measured, conflicts are overpassed and the chances of having a successful business increase.

It is now helpful to look at project management from two different perspectives: how the project fits into the organization; how the project will evolve over time, defining thus the life-cycle. Therefore, to help understanding the process of the industry analyzed in this thesis, a brief introduction to the Process Groups will be presented.

2.2. Project Process groups

Projects are temporary structures with the specific aim of delivering a unique end-product and therefore will have an identifiable life-cycle, with each phase producing a deliverable that brings the project closer to the desired output. The five process groups are Project Initiation, Project Planning, Project Execution, Project Monitoring and Controlling and Project Closure. Each of these phases is made up of a number of activities that vary depending on the scope of the project.

The project phases, ***Figure 8***, are linked by the respective inputs and outputs, as the outcome of one process will be the input of another. Each phase has a beginning and end point, even though most of the times the relationship between the phases will not be sequential, with a phase starting only when the previous one has ended, but will have some activities parallelized. In fact, even though the overlaps increase the risks and costs of the resources, they allow a fast-tracking scheduling that shortens the duration of the project.

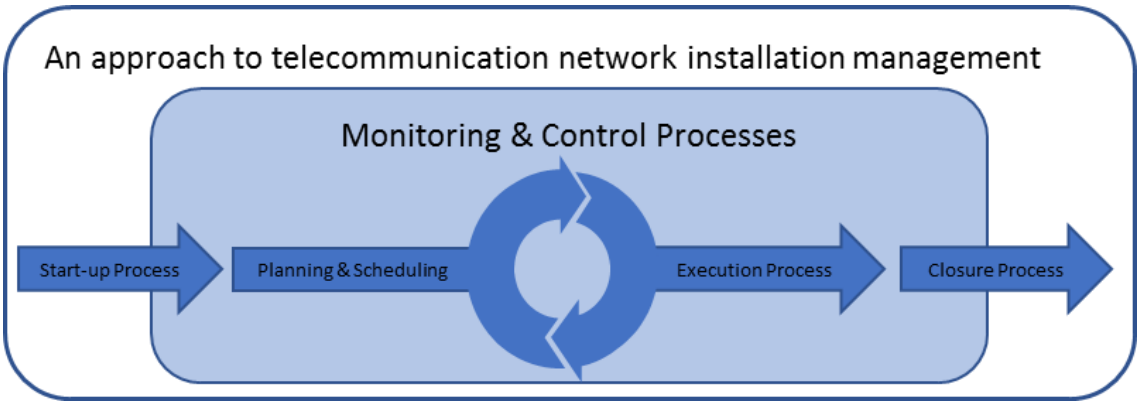


Figure 8 - Flowchart of a project with single activities

The Initiating process group, with a preliminary evaluation of an idea and a feasibility study, defines and authorizes the project. In this phase a clear description of the project, including the documentation with a basic description of the scope, is presented to see the project is aligned with the strategic plans of the company's portfolio. If all the steps of this phase are passed, the project is officially authorized.

The elements that characterize the Initiation are:

- Feasibility study: used to understand the problems, opportunities and needs of the project aiming at selecting only projects with a high possibility of success, a strategic significance and high quality. Through this study a forecast for the decision makers is also presented.
- Creation of a project team: since normally the bidding phase is performed by other managerial figures, it is only during the initiation that a project manager is assigned and the required resources are obtained. To form the right team, it is important to have complementary resources that are able to adapt both to the situation (making them suitable for the customers' requests) and to the team.
- Project Charter: document that authorizes the existence of a project, helping at the same time the stakeholders to define the direction of the whole project. It is made of five different parts: description of the purpose and the objective (which must be SMART, specific, measurable, achievable, relevant, time-based); definition of the milestones in terms of time and costs that will be significant to the project; creation of acceptance criteria that define

how to quantify the quality of the output; identification of risks, assumptions and constraints; and definition of the stakeholders.
- Kick-off meeting: meeting where all the team members, executives and customers take part, where the PM (project manager) meets the team and gains the commitment by explaining the project goal and setting up a way of communication.

The Planning provides a more specific definition of the resources requirements, schedule and costs to meet the project scope. However, since during the Execution some features might be discovered, the documents presented in the planning might change. In this phase, also the major risks and opportunities must be considered. The processes included are:

- Creation of the Work Breakdown Structure (WBS), a deliverable-oriented hierarchical decomposition of the work to be executed, used to provide a framework for organizing the project scope. The WBS must be exhaustive and the activities included must be mutually independent.
- Activity sequencing: definition of the specific activities performed to produce the deliverables. In this phase it is not important to identify a precise schedule as the focus is on the prioritization rules that define the relationship between the activities and their interdependency (F2S, F2F, S2F, S2S).
- Resource, duration and cost estimation: creation of an Organization Breakdown Structure (OBS) that consider all types of resources (manpower, assets, technologies) and estimates the type and quantity of resources needed in each scheduled activity. For the duration estimation either expert judgement is used or techniques such as the three-point estimate. While for the costs, the Cost Breakdown Structure (CBS) is created and, by associating the costs to the resources and WBS activities, a cost budget is defined.
- Project schedule: through an analysis of the sequences, durations, resources, requirements and schedule constraints, a project schedule is defined and represented in a Gantt chart and Network Diagram. In this phase one of the factors that must be observed is the critical path, which represents the longest path. In fact, if we want to shorten the duration of the project, this can be achieved only by transferring resources from other paths to the critical path.
- Communication management: to determine how to communicate the right information, at the right time, to the right stakeholder, through the right channel.
- Human resource planning: process that identifies the roles and responsibilities.
- Quality management: process that identifies the quality standards relevant to the project.
- Risk Management Planning. Risks are uncertain events, characterized by the probability of occurrence and impact, that can have a positive or negative effect. It is very important to identify the ones that might affect the project and consider them either as assumptions and constraints, or as tasks in the WBS (in case of high-level risks). Based on the impact and probability, a risk can be avoided, by changing the plan; transferred to a third party; mitigated or accepted.

The Executing phase involves coordinating people and resources to perform the activities scheduled in the plan and accomplish the project's requirements. It is very important to collect the information over the completion status of the deliverables to support the performance and monitoring reports. In the Execution phase, also the changes are taken into consideration by looking at their effect and deciding thus if accepting or rejecting them. Change control is necessary because it is very rare that projects run exactly according to the plan.

The Monitoring observes the project execution to timely identify the potential problems. By collecting, measuring, and controlling the performance indicators assessing the measurements and trends, it is in fact possible to start activities that will improve the performance of the project. The focus will be on the high-risk tasks, analyzing and tracking them to make sure that the correct response plans are used; the project progress, comparing the actual performance against the plan and determining whether corrective actions are necessary; the costs and the team performance, to update the schedule information and analyze the progress compared to the project plan. In order to have a performing monitoring, it is important to keep track of the progress of the project, both through documentation and meetings. If, for example, during the monitoring phase it is seen that the project is running late, the management could respond in four different ways: allocating more manpower, replacing the resources with more efficient ones, changing the scope or improving the working methods and tools.

The Closing phase formally terminates the activities of a project by either handing off the final output or by cancelling a project. Several aspects must be taken into consideration in order to assess the quality of the overall project. The aspects that are analyzed are: financial (by looking at indicators such as the ROI), time (by checking the consistency of the project), quality (through the client's opinion) and environmental. An overview meeting and a project overview document are provided as closure.

2.3. Project Organization

Looking at the organization's perspective the most important channel of communication between portfolio managers, program managers and project managers is the Project Management Office (PMO). An entity that is responsible of coordinating projects by monitoring and collecting data from them supporting thus the project managers in their work. In fact, if there is a significant number of projects and programs, it might not be possible to conduct a successful portfolio management alone but through the PMO it is possible to ensure that standard processes and procedures are in place.

The PMI defines the PMO as "an organizational body or entity assigned various responsibilities related to the centralized and coordinated management of those projects under its domain", it interacts directly with the top-management to update the project progresses and at the same time, depending on the type of organization, it has also a stakeholder role in the portfolio management. Of course, the more Project Management is used within the organization, the more the PMO will have an important and effective role.

The main responsibilities of the Project Management Office can be identified in:

- Managing shared resources, by moderating the conflicts between project managers, through prioritization rules, working as a support for the portfolio management.
- Identifying best practices, guidelines and procedures that are adopted as a methodology by all the projects. This is one of the main challenges that the PMO faces; in fact, achieving a common set of processes that are accepted by all project managers is not always easy.
- Providing training and coaching to help the project manager to understand how the processes are applied.
- Monitoring the progress of the compliance to the policies.
- Providing performance results.

- Assisting the risk identification and strategy by maintaining a shared contingency budget to direct it towards the projects that are more in need.
- Maintaining data by keeping the documentation and metrics related to the practices implemented in the projects within the organization.
- Keeping communication channels active so that the information can be forwarded.
- Updating project managers about internal and external changes that may affect the project.
- In some organizations it works also on implementing project management methodologies.

If the PMO is not correctly created and used, it will not be well received by the lower levels of the organization, where it will be seen as just another layer of corporate bureaucracy between them and upper management.

The responsibilities that are identified in the PMO are:

- Top Management: through the information coming from the Portfolio Manager it defines the company's strategy.
- Project Manager: authority to manage the day-to-day work of the project, leading the planning and development of project deliverables. They are responsible for the effective planning, executing, monitoring and closure and report to the portfolio manager and to the PMO.
- Program Manager: role responsible of the overall program structure, focusing on how to align it to the portfolio management plan. The PMO supports the Program Manager by providing information and administrative support.
- Portfolio Manager: authority who makes decisions about the investments and priorities for the portfolio ensuring that it fits the company's strategy, taking care of how the information flows within the company.
- Project Sponsor: person that starts the project by providing the funding, resolving the issues and the scope changes.
- Steering Committee: group of high-level clients and stakeholders whose responsibility is to prioritize the work by providing resources and support for the projects, providing strategic guidance and monitoring the results.

2.3.1 Organizational Structures

As it was several times stated, the telecommunications' industry tends to be Project focused. Therefore, their management structure will be designed to support the projects in the best and less costly possible way. In fact, the way in which an organization is structured is largely affected by its day-to-day work. In the literature, four main types of organizational structures are identified: functional, divisional, matrix and task force.

In the functional structure, ***Figure 9***, the organization is grouped according to purposes (for example, there will be a marketing, a sale, a production department). This structure works for businesses that have a small variety of outputs offered or with a long life-cycle, in which each department works in a highly independent way from the other departments. In fact, these companies require less reactivity, since the business is rarely affected by deviations, and are more focused on cost reduction through economies of scale, efficiency and strong functional knowledge. However,

this structure can bring to coordination problems with a strung bureaucratization of the transmission of knowledge and thus a smaller growth of the diversification of the Portfolio.

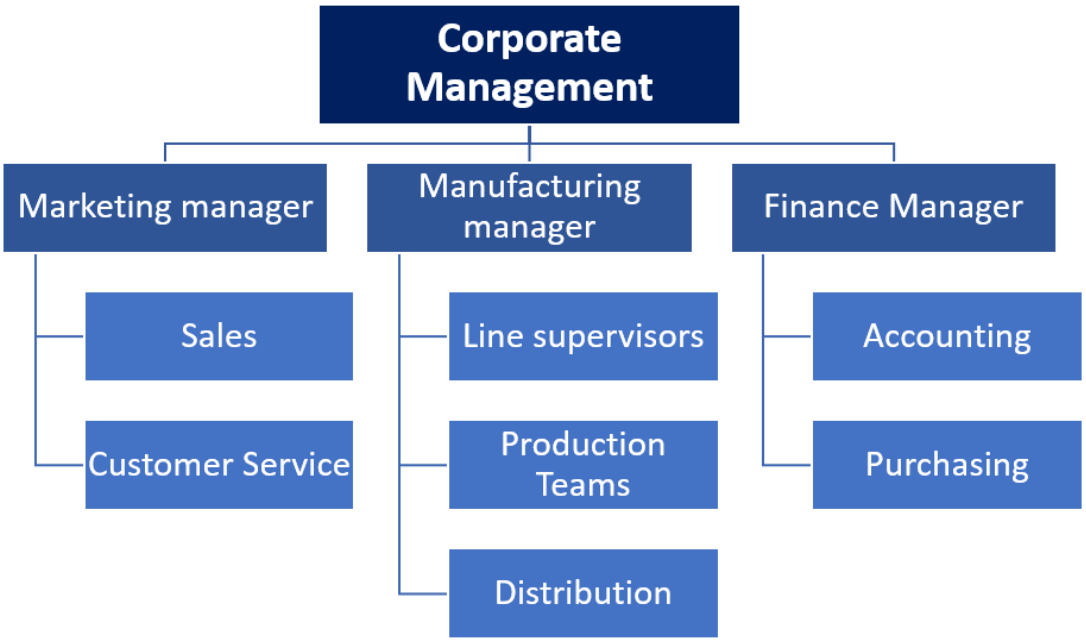


Figure 9 - Functional Organizational Structure

On the other hand, the divisional structure, ***Figure 10***, organizes the company in smaller organizations each covering different types of products or market areas. The benefit of this structure is that needs and deviations to the forecasts can be addressed more rapidly and specifically, allowing at the same time a growth of the portfolio offered by combining the knowledge coming from different areas. In this scenario the senior management allocates capital to each division, which then operates autonomously. The structure is thus costly since each business unit will be, in a smaller scale, part of each division; and the lack of control and coordination can bring to internal conflicts between the different divisions and thus to a smaller growth of the business. Looking at the advantages brought by this structure, it will fit mostly the companies that require fast adaptation to market changes with an heterogeneous portfolio of products and a short life-cycle.

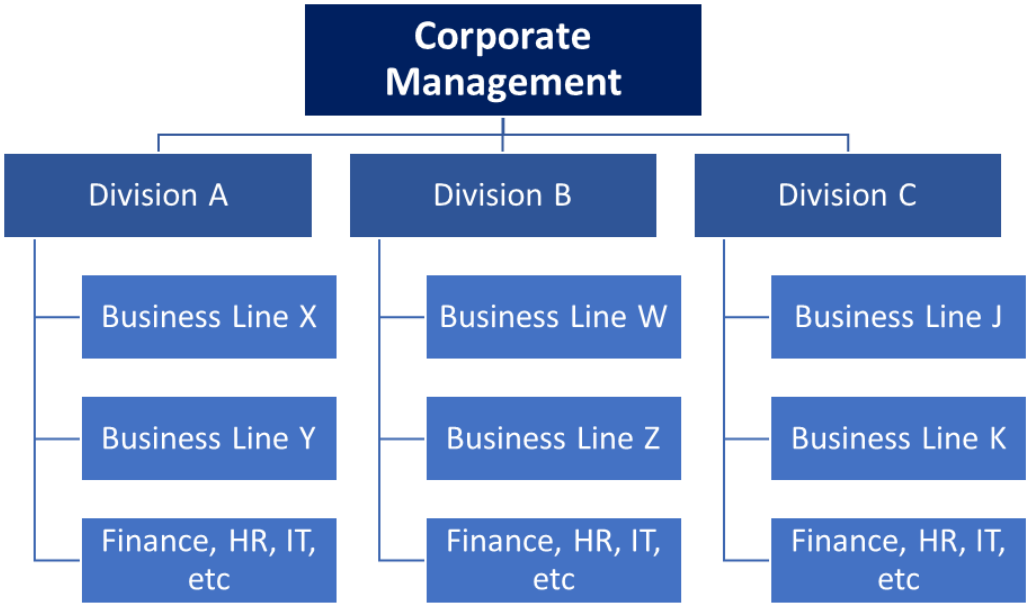


Figure 10 - Divisional Organizational Structure

The matrix structure, ***Figure 11***, is a hybrid of the functional and divisional structures. Here each division operated independently, but some functions are shared with other divisions enabling to save money, have a more specialized staff and have a quicker decision-making process. The resources will thus be used efficiently, and the goals will be more clear and shared; however, the fact that it creates a dual-management can create power conflicts (regarding both budget, resource allocation, prioritization, etc.), increasing at the same time the complexity of the organization. In this context, Project Management gets a high importance, introducing mechanisms of communication and coordination across divisions.

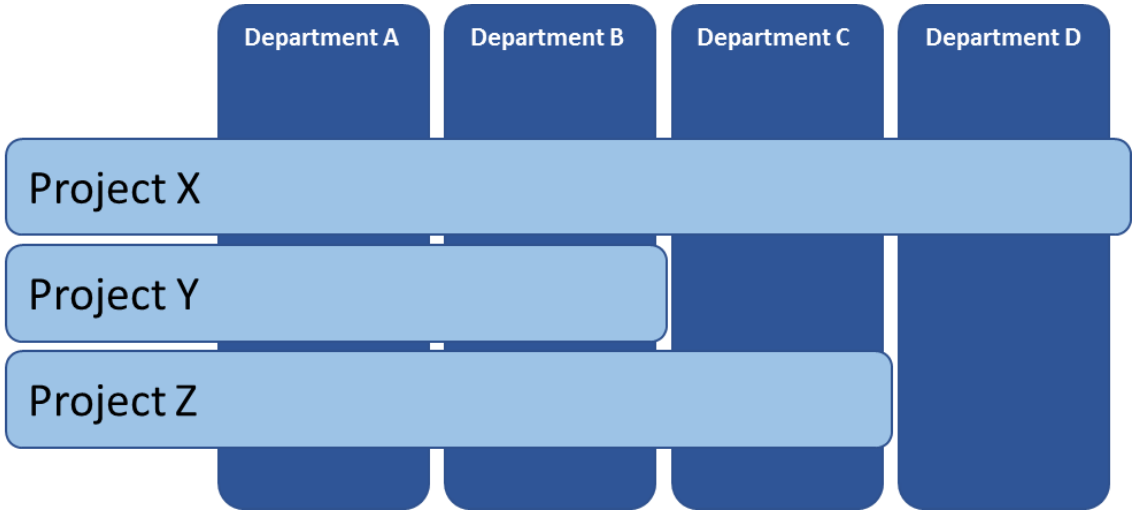


Figure 11 – Matrix Organizational Structure

If we look at a project-oriented matrix, the divisions will be the projects and each individual will be assigned to one or multiple projects reporting at the same time to the project manager and to his Line Manager. This latter structural type is the most used in the industry analyzed; in fact, through a matrix there is the optimal allocation of the resources between the projects. Of course, some problems will have to be faced, especially the ones regarding the disagreements between the Project and Line Manager. This happens since Line Managers have finite resources that they can allocate and, compared to the Project Managers, they tend to have a different view on which project has the highest importance. At the same time, being in several projects sometimes demotivates the employees that do not know if their effort will be recognized and awarded.

An evolution of the Matrix structure, when a project is more time-consuming and has a short time span is the Task Force, or Project Team. In fact, the task force is a temporary unit that brings together a set of specific and specialized skills exclusively under the Project Manager. This structure is essential when the project is complex and require a timely involvement of the resources; however, it tends to be very expensive and it requires more resources since these will not be shared to different projects.

2.4. Project Management Methodologies

In the previous chapters, project management was introduced by providing a general framework that defines each kind of project, regarding the size, nature, or type; however, when looking at its application in the real world, there are several practices or procedures that can be followed to control the process. Each of these contains guidelines and tools that support the decision making and problem solving, increasing the chances of successfully delivering a project in a certain scenario.

If we look at the literature, there are several methodologies that could be described and presented, going from traditional approaches, to hybrid methods that combine different materials. However, in the extent of this work, two approaches are of particular interest: the Agile and the Risk Management. The reason why these two methodologies were chosen is that they will play an important role in the second part of the thesis, when an optimization of the current project management model of the telecom industry, which will focus on the Agile and the Risk Management, will be developed.

2.4.1 Agile Project Management

The Agile Project Management was empirically developed in the software industry, where there was a quest for an approach that was suitable for large complex projects, with a high level of uncertainty, due to the difficulty to specify the outcome in advance, that caused frequent changes. In this context, a traditional Waterfall methodology, based on a systematic process that tries to foresee the evolution of the system, did not provide the required flexibility and responsiveness, and therefore, a new approach, that on the contrary allowed to quickly respond to the opportunities of the market and the requests of the customers, was developed.

However, even though the Agile methodology was developed for the software industry, also the construction industry, more and more affected by a high level of uncertainty, started to embrace

the agile values, attitudes and tools, to enhance the capability of responding to changes. In fact, through the iterative process proposed by the Agile Project Management, the company is able to progressively define the customer needs and requirements without having to predict the future already in the early stages of the project.

Even though the PMI does not provide a definition of the Agile Project Management, in the software extension of the PMBOK it is presented as an adaptive methodology that is change-driven, embracing and accepting a high level of uncertainty. An Agile Project Management has in fact the advantage of being more reactive to the changes, taking into consideration the risks that could come from this high variability, as it allows to start a project without having the scope well defined. While a traditional methodology, which is defined by a very structured process, would emphasize the customer's requirements by early defining them, the Agile divides the project into small increments, called Sprints, that give the opportunity of reviewing the past cycles and plan the future ones without having to focus on setting up goals to delivering the entire project. This difference is underlined in the four main values that define the concept of Agile Project Management: individuals and their interactions over processes and tools, working software over comprehensive documentation, collaboration with the customer over negotiation of the contract, responding to changes over strictly following the plan. These points were the basis for the development of the "*Manifesto for Agile Software Development*[1]", which defines the twelve principles that are the basis of the agile movement:

1) The highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2) Change requests, even late in development are welcome.
3) Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to a short timescale.
4) Business people and developers must work together daily throughout the project.
5) Projects have to be built around motivated individuals, giving them the environment and support they need.
6) Favor face-to-face communication as it is the most efficient and effective method for conveying information.
7) Measure progress through the quality of the working software.
8) Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9) Continuous attention to technical excellence and good design enhances agility.
10) Simplicity, the art of maximizing the amount of work not done, is essential.
11) The best architectures, requirements, and designs emerge from self-organizing teams.
12) At regular intervals, the team reflects on how to become more effective, then adjusts its behavior accordingly.

[1] The definition of Agile Project Management was drafted by seventeen experts of software and project management through twelve principles; these can be found, together with the names of the high profile figures that supported the development of the methodology, at the webpage http://agilemanifesto.org/.

While a traditional approach focuses thus on trying to predict and analyze the functionalities and the requirements before the beginning of the project, to then forecast the costs and time; the Agile approach postpones the decisions concerning the functionalities, focusing on the resources (costs) and time necessary and available for the project, ***Figure 12***. In this way, instead of spending time to planning every detail of the project, which, given the industry, would not be stable, it embraces the change by controlling the costs and time related to it. At the beginning of each cycle, there is thus the opportunity to change the direction or the requirements of the sites, if these do not impact the resources and costs.

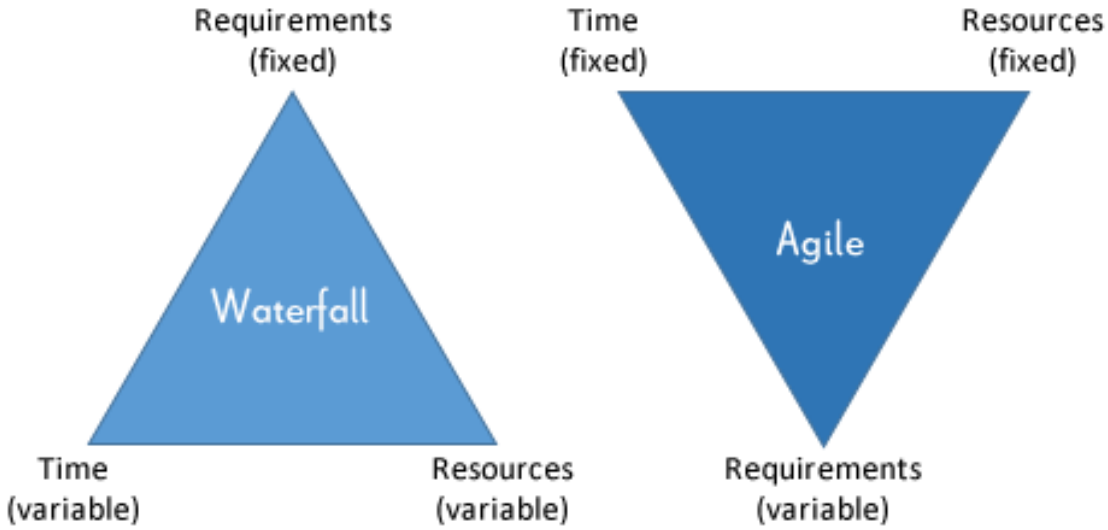


Figure 12 - Comparison of Waterfall and Agile methodology

It is important to bear in mind that in this context the *stakeholders* have an active participation in the project, as without their strong collaboration the high level of uncertainties would not be accepted. Before each iteration the stakeholders have to both provide the requirements expected to be achieved through the new sprint and a feedback of the previous iteration to ensure that the solution is feasible and in the direction of their expected goal. Which means that even though the methodology aims at being flexible and dynamic, to ensure that the project team is reactive to the changes coming from the customer, there has to be also some coordination and structure otherwise the relationship between the parties will be hard to manage. The process is thus defined by a structure that describes the steps of each stage, while including iterative outputs that fit to the flexibility requirements.

2.4.1.2 The SCRUM methodology

Even though in the literature there are several developments of the Agile methodology, the most common and spread, and at the same time the most relevant for the telecommunication construction industry is the Scrum. This methodology started to be used in the nineties but was

defined only in 2000, when Ken Schwaber [2] and Jeff Sutherland [3] defined the Scrum as "*a framework within which people can address complex adaptive problems. Scrum is not a process or a technique for building products; rather it is a framework within which you can employ various processes and techniques. Scrum makes clear the relative efficacy of your product management and development practices so that you can improve."*[4]

The Scrum is simple to understand and lightweight, however it is difficult to master; in fact, it is not founded by a strong theoretical process, but it is based on empirical processes that come from experience. To correctly apply the Scrum it is therefore important to first enter in the mentality of the process, accepting that it is not possible to have a complete overview of a project since the early stages and that the only solution is to have the resources and tools to promptly respond to changes.

The Scrum theory is founded on three pillars: transparency, inspection, and adaptation. Transparency is about creating a common vision that is shared between all the team members; in this way, even if there is not be a structured process, there is a common language and an understanding of the significant aspects by all the team members. Inspection is not meant as the monitoring of the classical Project Management, where it was used to prove that what was forecasted actually took place, but as frequent action, performed with a critical attitude, to analyze the current situation and how it could influence the future. Adaptation, which comes to not being overwhelmed by the output of the inspection, but adjusting the deviations.

On an operative point of view, the Scrum is based on three phases: the *Pre-Game*, the *Development* and the *Post-Game*. The *Pre-Game* deals the interaction with the customer and the definition of the *Product Backlog*, which is a list of all that might be needed to succeed in the project; it includes all the requests coming from the customer and will thus never be complete, as updates and changes will modify it throughout the project. At the end of each Sprint, the backlog is in fact updated and as the project gains value, the Product Backlog becomes bigger and more exhaustive. During the Pre-Game, the developer has also to define the effort that each item of the Backlog requires, in order to estimate the effort and to choose the right amount of items to develop during the Sprint. The *Development* is characterized by the Sprints, which normally last from 1 to 4 weeks, where the actual production takes place. The *Post-Game* aims at delivering the final output by integrating the functionalities into it and taking care of all the aspects connected to it, such as the testing and training, ***Figure 13***.

[2] Ken Schwaber is the co-founder of the Scrum framework, as well as one of the signatories to the Agile Manifesto in 2001, and the founder of many associations such as the Agile Alliance and Scrum Alliance.
3 Jeff Sutherland is the co-founder of the Scrum framework, as well as a supporter of the application of the scrum methodology outside the software industry.
[4] Citation from "The Scrum Guide – The Definitive Guide to Scrum: The Rules of the Game", written by Ken Schwaber and Jeff Sutherland.

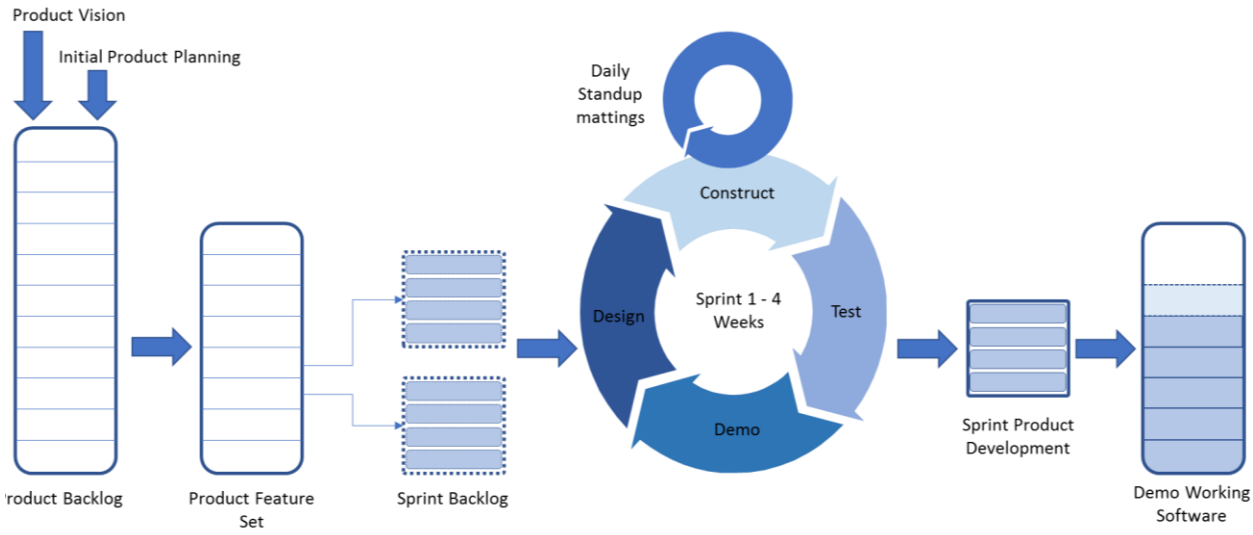


Figure 13 - Software Development scheme through an Agile Methodology

One of the most important characteristics of the Scrum is the importance that is given to the meetings. Of these, the two of most relevant impact are the *Daily Scrum* and the *Sprint Review*. In both cases a strong emphasis is given to the duration of the meeting as they must be time boxed to a predefined length in order not to lose sight of the goals. The *Daily Scrum* is a daily meeting where the team is updated about the progress of the project, the daily activities are organized and, if new requisites emerge, the Project Backlog is updated. The meetings are time-boxed and very fast (normally around 10 minutes) and it is therefore important to focus on the most relevant points that could have a greater impact on the output. Giving this daily timebox to the team increases the chances of meeting the goal of the Sprint as the team members can openly discuss about the pain points faced to adapt or re-plan the rest of the Sprint. The *Sprint Review* is a 4 hours meeting held at the end of the Sprint, where both the implementation team and the stakeholders take part, and it aims at inspecting the output and adapting the Product Backlog with the requisites that emerged during the Sprint. It is important that in this meeting the stakeholders understand the progress made, the goals that were reached and the ones that were not to increase the potential of the subsequent Sprint and to adjust the project through corrective actions.

The Scrum Team is made of four main figures: the *Scrum Master* who has to ensure that the process, practices and rules are understood and correctly applied by all the team members; the *Product Owner* who is responsible of the project and of the strategic decisions, deciding the effort that will be put into the Sprint and accepting or refusing its results; the *Scrum Team*, which is the development team that creates the increments, which means that in order to have efficiency and effectiveness the number of member has to be kept low (normally between 3-8 members); the *User*, who is the final adopter of the output.

2.4.2 Risk Management

While Agile Project Management is described to introduce a flexible approach, which can be used in a context with high variabilities and uncertainties, where the deliverable is not entirely defined and described from the early stages of the project. Risk Management fulfills a second function aiming at increasing the chances of success of the project, by following a procedure that manages the risks that can be encountered during the project. This becomes extremely important in a context with high variabilities, such as the industry analyzed, but also in other environments. In fact, in an era of globalization with increasing competition, companies try to constantly look for blue oceans, a business where very few firms operate and the pricing competition is not as fierce. This strategy, together with the uncertainties given by the environment, bring to having to deal with risks.

Even though the concept of risks is often associated to negative conditions related to uncertainty, damages and unfavorable impact, the definition of risk has a neutral meaning, and the PMI presents it as "an uncertain event or condition that, if occurs, has a positive or negative effect on one or more project objectives such as scope, schedule, cost, or quality". A risk is thus an uncertain event that can both have negative and positive impact, with a known (or assessable) probability of occurrence and with a measurable impact.

When looking to the risks that affect the outcome of a company, these can be considered either in a separated way, so as individual risks, or as a single value, representing the overall risk of the project. This distinction is mainly affected by the enterprise position that is interested in the topic; in fact, while a project manager, who is responsible of the outcome of the project, is interested in each risk that could affect the quality of the output, in its probability of occurrence and in its impact on the project, to determine how to split the effort of the resources to reduce the chances of the negative risks and increase the ones of the positive; on the other hand the project sponsor does not want to know about the specific risks, but about the riskiness of the project as a whole. On this matter, it is important to understand that the project overall risk is not given by the sum of the individual risks as there are much more variables that are taken into consideration, as for example the exposure of the stakeholders.

No matter the role interested on the risk, every project has risks, and it is important that the company develops a procedure to manage them as the chances of reducing negative risks and enhancing the opportunities has a positive effect in the outcome and thus is the profits of the company. For this reason, the idea of Risk Management started to be analyzed, bringing to its definition as "the systematic process of identifying, analyzing and responding to project risk. It includes maximizing the probability and consequences of positive effects and minimizing the probability and consequences of adverse events to project objectives" (PMBOK). Through risk management a rational chain of practices can be identified making the handling of the risks more smooth and facilitating the decision-making and the execution actions against them.

The methodology of risk management considers four stages:

- Identifying,
- Assessing,
- Responding,
- Monitoring.

The aim of the procedure is to transform random uncertainties into a measurable value that can be monitored. This is achieved by firstly selecting all the risks that could affect the achievement of the goals of the project, to then organize them depending on their impact on the outcome in order to facilitate the identification of procedures and actions to respond to the risk. Over the course of the project risks are then constantly monitored to promptly react to them.

2.4.2.1 Risk Identification

The importance of risk identification lays in the fact that the risks that are identified in the early stages are the easiest to handle. If a project team manages thus to carry a deep and exhaustive risk analysis, corrective actions can then be identified to avoid that, if the risk occurs, the project team is not prepared to respond to it. Moreover, in this conceptual phase the sponsor is able to eliminate or limit those risks that could have a strong impact without the project team being able to take any corrective actions. These are normally removed either through agreement with the customer, or with contracts with third-parties.

In order to identify all the risks associated to a project, it is important to firstly determine all the sources that influence the output of the project and whose activity should thus be monitored. This can be achieved through two different techniques:

1) Cause-effect, which starting from all the causes that could bring to deviations to the basic and define progress of the project, aims at identifying and measuring the consequences. This technique is commonly called Event Tree Analysis (ETA) and is a bottom up approach as it starts from the causes to identify the effects. It is important to note that from a risk several more can be generated, which means that the output of the ETA is an event tree that shows all the paths that could be followed to reach the goal.
2) Effect-cause, which goes the opposite way and starting from the effects, distinguishing them into positive and negative, aims at identifying the actions that have to be taken in order to reach a positive outcome. This technique is commonly called the Fault Tree Analysis (FTA) and is a top down approach as it starts from the undesirable effects to then identify its roots.

In both cases to identify an exhaustive list of the possible risks of a project historical information and experts' interviews are used. In fact, both can provide a starting checklist with the major situations that have impacted similar projects in the past.

Once risks have been identified, these are classified into macro areas, which vary depending on the industry. In the construction industry the main categories are: financial, schedule, and design. The financial risks are the ones that can have internally the strongest impact, as they involve an increase in the costs that could bring up to a negative profit. These can be of several types, going

from the instability of the economy of a country, to its inflation, to the costs that arise due to a lack of precision during the contractual phase. Scheduling risks are the time-related ones connected to the failure in reaching the implementation goal. The scheduling is something that cannot always be controlled, which as an outcome still bring to financial problems, as there are out of scope actions that can impact it, such as the weather condition, the absence of the employees due to sickness or protests. Design risks are associated to technical failures when deciding the technologies that have to be used. In this case risks are connected to the ability of identifying the proper design that fits both the environmental requirements and the quality standards of the client.

In all the risk categories it is important to distinguish when a risk is internal or external as this impacts the measures that will be taken to respond to it. In fact, while an internal risk is generated within the project and can thus be controlled by the project team, an external one is not under the direct control and the team can only be aware of it and on the impact that it can have.

The output of the risk identification is a Risk Breakdown Structure (RBS), ***Figure 14***, a hierarchical representation of the risks of the projects starting from the macro areas to then subdivide them into classes and further decompositions.

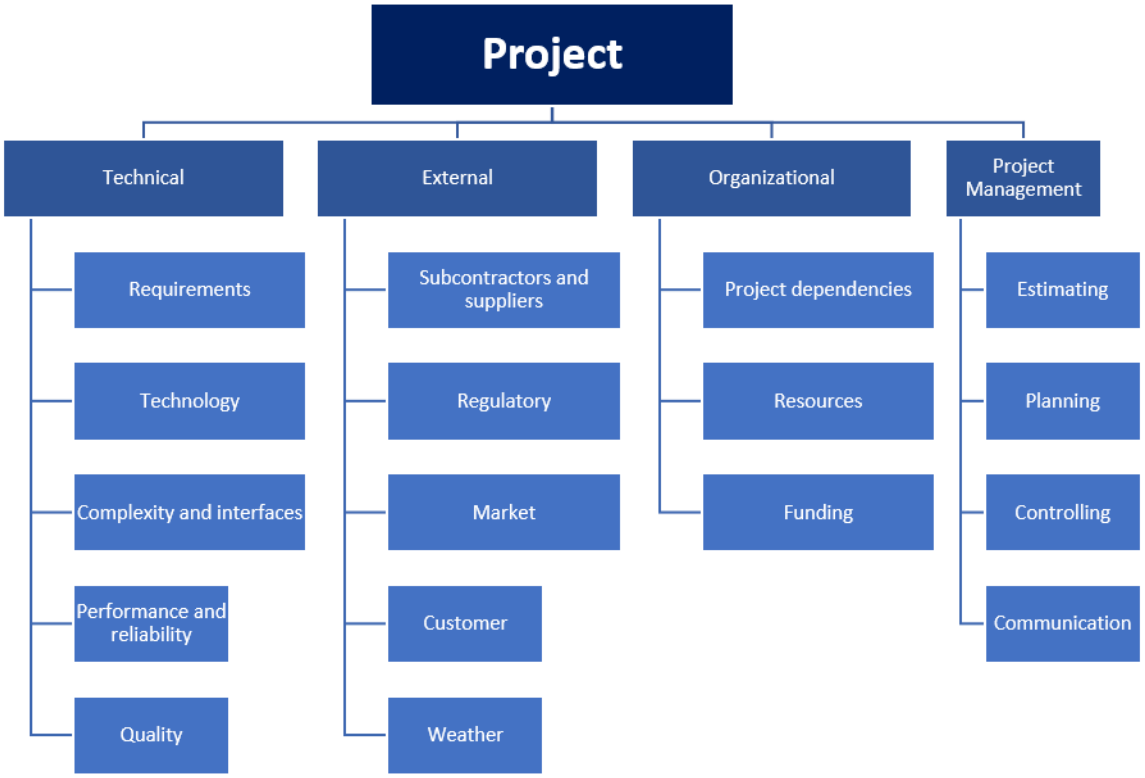


Figure 14 - Example of a Risk Breakdown Structure

2.4.2.2 Risk Assessment

Once risks have been identified they have to be classified based on their impact on the project and probability of occurrence; in fact, risks that happen very seldom or that have a minor impact are less urgent and can almost be avoided, while major risks have to be monitored in order to prevent their actualization. In the risk assessment the main goal is to identify the potential losses or gains coming from a risk as through this deeper analysis the project team is able to create proper contingency plans to respond when risky events occur.

In this stage the RBS is related to the WBS through a matrix and the interception between the two axes is filled with the estimation of the economic impact, known as risk exposure, of the selected risk over the selected activity. The reason why risks are related to an economical value is that in this way they can be included in the budget estimation, being included as a contingency budget that is used as a cost buffer to cover the risks that could occur over the project lifecycle. The risk exposure is calculated multiplying the economic impact of a risk with its probability of occurrence, $R = p * I$, the reason why the probability is introduced is that the project team has to focus only on the major problems that have yes a strong impact but also a high probability of taking place as spending time to manage risks that happen rarely would only be a waste of money and time, even though their impact could be high.

In order to define the impact of a risk both qualitative and quantitative method can, and are, used. In fact, a qualitative analysis, which is based on the use of "word values", facilitates the identification of the hazards that have a highest priority establishing a way of taking decisions over based on the risk category. Typically, this approach is used to classify risks in three macro areas: very important risks, when the probability is high and the impact critical, medium risks, and low risks, when the probability is low and the impact is marginal. On the other hand quantitative analyses, which is based on numerical values, is used over the output of the qualitative one to determine with high accuracy the probability and costs based on the risk, focusing especially on the most important risks. In order to have a good output, a company has to possess a lot of historical data that supports the calculations and a lot of knowledge over the project.

2.4.2.3 Risk Response

Both the qualitative and quantitative analysis are used to determine the probability of occurrence of a risk and its consequences in terms of monetary value; however, once these have been identified it is important to establish countermeasures to increase the chances of saving profits and minimizing the losses. In fact, based on the relationship between probability and impact, each category of risk has one of the four different reactions, ***Figure 15***:

- Accept
- Transfer
- Mitigate
- Avoid

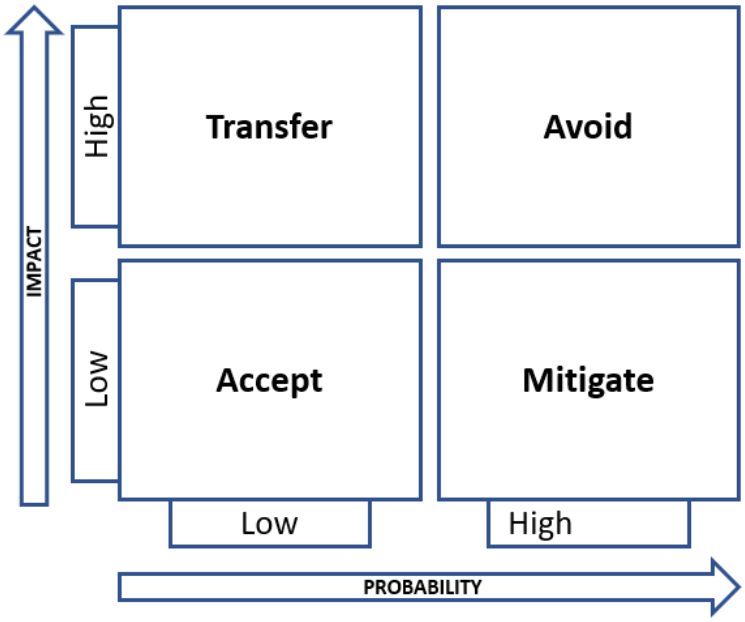


Figure 15 - Classification of Risks based on Impact and Probability of occurrence

A risk which has a low probability of occurrence and a low impact is accepted, as spending time and financial resources over it would most likely not bring to benefits. This does not mean the these risks are not monitored, but just that corrective actions will not be taken to mitigate their impact before the beginning of the project.

A risk that has a low probability of occurrence but a high impact, especially when it is connected to external causes, is transferred to a third-party. In fact, a company has no interest on bearing risks that are out of its scope of control, and, in this case, insurance policies are created to transfer the ownership of the risk to another entity, preventing the losses to be borne by the company itself.

A risk that has a high probability of occurrence but a low impact is normally mitigated, which means that preventive actions are taken to overcome the effects of the risk. When choosing if mitigating a particular risk or not, a company goes through a cost analysis by comparing the risk exposure to the cost of the preventive action. In fact, it would not make sense to implement a mitigation plan if its cost are higher than the impact of the risk in case of occurrence. In this case, a solution might be to consider a corrective action that partially mitigates the risk and include a contingency budget for the remaining part.

A risk that has a high probability of occurrence and a high impact is avoided, which means that the process has to be re-considered and re-planned by considering alternative solutions that allow to avoid the risk from existing, including in some cases the decision of giving up in investing on a project that could bring to losses.

2.4.2.4 Risk Monitoring

Risk monitoring is applied to keep under control those risks that were accepted or mitigated by providing plans that consider the actions that have to be taken and the resources that are responsible of the actions in case the risk occurs. In fact, if counter measures are well-defined the response to the risk runs more smoothly.

It is important to note that in this phase, through a constant evaluation of the project to check and evaluate the impact of the risks that are kept under control in a continuous changing environment, very often the project team is able to determine further risks that were not found in the identification analysis. These bring to a continuous cycle of risks assessment and response to determine the actions for each new risk that is identified. Of course, the more a company becomes familiar in an industry and the more a company is involved with similar projects, the less should be the risks not identified from the early stages. This is one of the reasons why experienced companies normally have fewer risks of failing than the new comers and at the same time are more afraid to move towards unknown businesses where the historical data availability is low.

3. The Telecom Industry

As stated in the introduction chapters, this thesis will focus on the work developed by companies that deliver a service to the Telecoms, focusing on the three main end-to-end solutions: Network expansion or optimization, business networks, and establishing temporary networks, as naming convention these companies will be named as Vendors. Being in this position gives to these companies quite an advantage since they realize the most valuable step of customer value creation, giving them the possibility to improve the customer satisfaction with high-quality and efficient service deliveries.

What matters for a company is profit, which is the financial gain that remains if the revenues are higher than the costs. To increase profits two strategies can be sought: increasing the revenues by exploring blue ocean services or technologies, or reducing the costs by offering standardized deliveries. Looking at the first option, the revenue increase, the telecom industry pushes constantly in the blue ocean direction as the profit of the carriers, who produce the "last mile" of the value creation, is based on how many users they have, and having the most advanced technology in terms of performance and reliability can increase their market share. Innovation is thus one of the greatest sources of competitive advantage; operators are constantly looking at enhancing coverage and offering innovative solutions customers and the Vendor that is able to "anticipate the future" by offering a technology that is not yet in the market, but improves significantly the customer satisfaction, can gain a lot of bargain power increasing its revenues. Therefore, the Vendor that is constantly able to innovate itself, through technology lifecycles that constantly produce new value for the customer, is the one that succeeds in the market.

At the same time, even a new technology at some point will start to become the standard and thus, what starts to count for a company is the sought of cost reduction. Reducing costs has a double advantage: on one side a higher opportunity to make revenues, on the other, the chance to increase the market share by reducing the price to the customer. In fact, the price that the customer will pay for the whole network implementation, called Total Cost of Ownership (TCO), will be given by the total cost of the IT equipment, including the installation, the software licenses, the service, the support, the training and all the other costs related to the product. The costs that define a project can be summarized into two macro components: hardware (including into this category also the software) and service (including the civil works, trainings, maintenance). The cost of a site can vary depending on where it is built and the stage from which it starts as of course a new build, where the whole station has to be constructed, is more expensive than a technology upgrade. This is especially due to the fact that the service is a lot more expensive than the hardware. To reduce the cost of the hardware two strategies can be followed, standardizing the process and achieving economies of scale, in order to have an efficient process that runs smoothly and that allows a batch production. To reduce the cost of the service, on the other hand, it is of extreme importance to increase the efficiency of the process, to reduce the number of mistakes and the necessity of re-workings, by introducing tools and protocols that promote the coordination and by having a tight relationship with the Partners to push a more accurate rollout that reduces the movements of the teams. Among the service costs, the maintenance is one of the factors that keep the business more expensive. In fact, quality issues related to the upgrade of the sites are owned by the Vendors for a long time after the site is built, and Vendors have to normally bear high costs to deliver a high quality output. Introducing a standardized process, with quality checks is one factor that can decrease the costs of the service the most.

On a project management point of view, the quest of blue ocean strategies and cost reduction, looking at a single project, has a two stages impact: in a first phase, there will be a request of financial resources to intensify the activity of the R&D department, increasing the headcount and time effort put into exploring new market opportunities. In a second moment, when the project will start to boost and increase its efficiency, less resources will be required in the team, and the project will start increasing the profits by reducing the costs. What actually happens is a cyclical process, in which there is a constant balancing between departments with many resources and finances and departments that are stable and profitable. To make it more clear, this situation is also visible from the technologies that were developed in the past years; when a lot of researches were being made over the LTE, the fixed network and the GMTS were working as cash cows, with stable profits and few problems. While nowadays also the LTE is entering in this stage, giving space for investments in the development of the 5G infrastructure.

It is important to always bear in mind that it is an industry with continuous business transformation and thus focused on change, with goals-shifts, project scope swings, variations in constraints and milestones. At the same time, strong competition among Vendors and compelling search for competitive advantages, together with a reduced time-to-market, lead to Vendors that must be capable to adapt and take more and more responsibilities. In this context, Project Management is regarded as a priority, in fact, the companies are yes involved in implementing new undertakings, innovations and changes, but at the same time, over time, some tools, management techniques and problem-solving approaches have recurrences. In this business it is thus essential to successfully run large and complex projects by adapting to variances and extreme conditions that each project can have through a standardized process, an optimal organizational structure and tools that correctly support the business.

Projects in the telecommunications industry consist of a portfolio of subprojects that have complex interfaces, international dimension, multidisciplinary activities, long-planning schedule and diversity of user requirements. The complex interface is given by the high number of interfaces involved in the project. Externally there are several providers that contribute to the delivery of the service to the end-users, which means that those will have to cooperate to offer a high-quality service. Internally, the communication includes having to manage both the network rollout team and the support systems teams. The international dimension is given by the expansion of carriers on a global scale; which means that also the service offered by the Vendors will have to adapt to different country regulations, different policies, different partners operations and different customer requests. Multidisciplinary activities are given by the amount of disciplines included in the service offered by the Vendors; going from engineering capabilities (in construction, design, electrical, computer science), to logistics, human resources, statistics, marketing and the huge impact of the legal department. Long-term planning relies on two factors: first, the partnership with the Customers tends to be of a long-term type, since the network has to be continuously updated and is easier and cheaper to do it without changing Vendor; second, the rollout project is extended to many sites that can be very spread, which means that a project can take many years to be completed. Lastly, the diversity of user requirements concerns the different goals that a Customer can have based on the area being developed, going from focusing on high-speed, to focusing on an extended coverage.

In the introduction, Chapter 1, it was mentioned how the Projects in the industry were of three different types: the first, focused on adding capabilities into an existing network, the second on

establishing a specialized business network for the enterprise business, and the third establishing a temporary network.

3.1. The network implementation business

The first type of services that the Vendors offer can be identified with: Network rollout and integration, customer support, consulting and assessment. The rollout and integration are what provide the customers with services helping the carriers strengthen their core capabilities; Customer support ensures the security, reliability and efficiency of the network; Consulting and Assessment provide service opportunities by assessing the customer's current conditions and pain points and analyzing how to improve the solution. The reason why a customer may rely on a Vendor or another, also lays on this point. In fact, certain companies provide a complete service that covers the whole life-cycle of a Network, ***Figure 16***, while others only focus on a certain service. Producing an end-to-end solution is advantage especially because it allows to reduce the costs, attracting thus more customers. However, at the same time, providing more services and having an expertise over the overall process of the business, increases also the opportunity of expanding the business and finding new profitable applications.

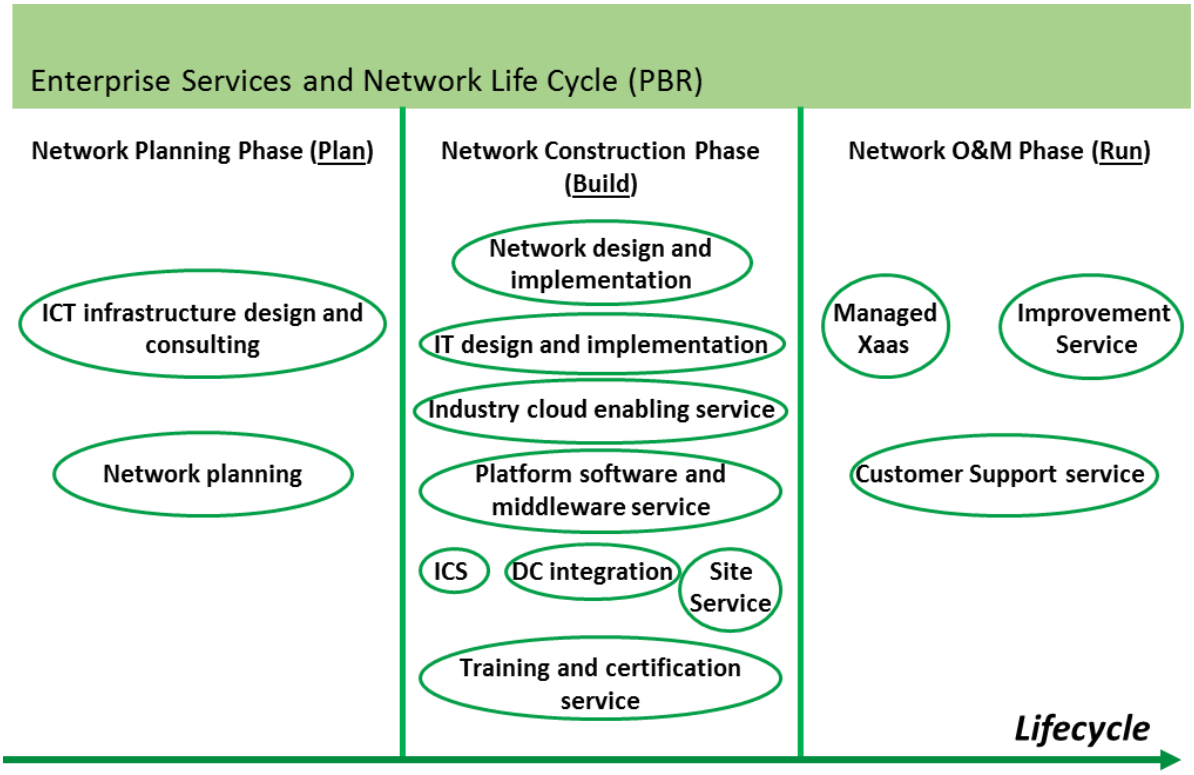


Figure 16 - Enterprise Services and Network Life Cycle

This thesis will focus on the Network rollout, as compared to the customer support and consulting and assessment, it is the element of main interest and revenue for the business. In fact, if we look at the business and at its continuous growth, we understand how important it is to upgrade and modernize it constantly. The spectrum efficiency is the most valuable resource in

wireless telecommunications and customers are constantly looking at ways of transmitting more data using less spectrum resources. The business has thus focused on what is called the "4M strategy": multi-carrier, multi-RAT, MIMO, and multi-brand technologies. Multi-carrier aims at exploiting multiple carrier waves all using the same standard, multi-RAT means converging different standards (2G/3G/4G), MIMO (multiple-input and multiple-output) means using multiple transmit and receive antennas, and multi-brand means using multiple spectrum segments to realize broadband speeds. In this direction, the 4M strategy aims at facing the main challenges of the business, which are: bringing the connection closer to as many end-users as possible, improving the speed of the network transformation to ensure a positive user experience, and lowering the operational and capital expenditure of the customers while maintaining the network quality.

To better understand the Network rollout, it is important to have in mind what defines a network. If we look at ***Figure 17***, representing an overall basic diagram of the 2G/3G/4G Network, it is already possible to understand how many components are required to provide an efficient solution and how important is the integration between the different services. Shortly, the transmission of data in a telecommunications system is made of two parts: the RAN (Radio access network) and the CN (core network). The first is the infrastructure that connects the devices with the core network, while the second is what provides the services to the users that are connected; in fact, it authenticates the users and provides paths for the information exchange.

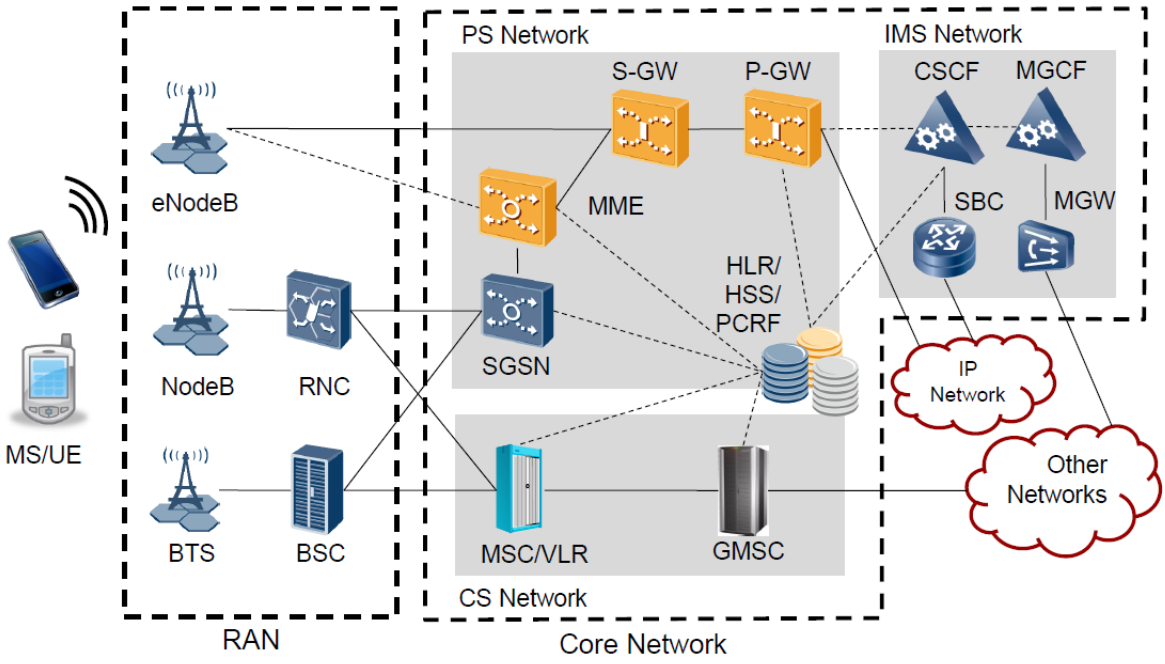


Figure 17 - 2G/3G/4G Network diagram

Depending on the standard that the mobile phones are using, the equipment that will be used, and the way the information will be transmitted will vary. The elements that define a RAN are: the BTS (Base Transceiver Station), which is an equipment that facilitates the wireless communication between the user and the network by providing radio communication interfaces for the 2G standard, the BSC (Base Station Controller), which is one of the most critical components since it controls a group of BTSs managing the transfer of calls when a mobile phone switches from one BTS to another, the NodeB is the equivalent of the BTS for the 3G standard, RNC (Radio Network

controller), is the equivalent of the BSC and is responsible of controlling the NodeBs that are connected to it, the eNodeB, is an evolution of the NodeB developed for the LTE transmission, the main advantage of the eNodeB is that it includes its own control functionality without requiring additional controllers such as the BSC or RNC. Through these components, the users are able to communicate, through calls, messages, or over the internet.

As mentioned, the price of a site can vary depending on the type of work that has to be processed. In fact, in a Network roll-out several services can be offered, most of which do not aim at upgrading the 2G and 3G networks but at consolidating the infrastructure and combining the 2G and 3G networks with 4G preparing the ground 5G-ready infrastructure:

- RAN Build: building new RAN sites, offering both site equipment and roll-out service, which means that the Vendor is responsible both of the network designing and installation and of the site engineering required to prepare the site. The current RAN architecture is not always optimal for the data transmission and it is becoming a barrier for the expansion and efficiency of the customers, who are facing years of increased data traffic and coverage demand. Dense sites are expensive to deploy as economies of scale are possible until a certain amount, if quality has to be kept. Therefore, the implementation of new sites that increase the geographical reuse of the spectrum is being more and more requested.
- RAN Expansion: expansion is used when it is still possible to increase the capacity and performance of a site by adding new equipment and software, in this case the Vendor will thus be responsible only of the designing and installation, while the civil works will either not be required or the customer will perform them with a third party. Through an expansion, new technologies are thus used over existing infrastructures to increase the capacity of the spectrum. As building a site from zero is expensive, customers try to push the expansion as much as possible before they decide to implement a new site.
- RAN Modernization and Swap: with the intensification of the competition between the carriers, upgrading and replacing old equipment with newer and more efficient ones allows to substitute items that have a low integration rate and a high power consumption with new ones that can provide a superior service reducing the capex (capital expenditure that a carrier faces to acquire and maintain a physical asset). The main advantage of the new equipment is that they support multiple standards over a single network. The SWAP projects focus especially on how to smoothly switch to the new equipment ensuring the performance of the network and reducing the interruption time that has to take place during the process.
- Build and Expand the transportation: upgrade the RAN sites with more efficient ways of packaging data such as optical fibers and microwave transport. Fiber optics allow to transmit information by turning electrical signals into light reducing the interference and latency and increasing the speed of transmission, microwave transportation allows to link small cells and fiber access points increasing the speed of the transmissions and the functions and parameters that a RAN can support. These two technologies are however very expensive and, especially the switch to optical fiber requires a lot of work and approvals since laying fiber means digging.
- Multi-vendor roll-out: most of the Vendors provide equipment that can manage a multi-vendor solution; this solution allows to reduce the TCO of the carrier by allowing the use of equipment coming from different vendors and thus being able to choose the cheaper

equipment, but loosing services connected to the support and maintenance after the site is built.

- Small Cells network: small cells allow to increase the efficiency of a spectrum by reusing frequencies without having to build a new site. The advantage of this type of rollout is that less civil works are required, however, on the negative side, the small cells have a shorter range and can thus ensure less coverage. Small cells are thus used especially in very dense indoor areas replacing the traditional antennas that did not offer a good coverage.

3.2. The Enterprise Business

A second business of extreme interest is the Enterprise business, an E2E (end-to-end) business that focuses on improving the efficiency and performance of business operations, using IT as a productivity enhancer, and user experience, using IT as an enabler tool by eliminating as many middle layers as possible. These projects are end-to-end solutions, which means that a tailored solution, both in terms of software and hardware will be developed increasing the efficiency of the enterprise by providing a service that responds to customers' pain points and strategic demands. In fact, industries are being more and more affected by new technologies, such as cloud computing, big data and IoT (Internet of Things) and the IT architecture and processes have to adapt to this new ecosystem. The rollout in the Enterprise business requires thus a bigger focus on reliability with backup recovery systems that reduce the risks that a company can face in cases of failure of the system.

In the past years, the enterprise business has become more and more profitable for the Vendors; in fact, ICT is becoming a core feature of competitiveness of an enterprise, increasing the efficiency of the production by providing process-based integration, involving systems such as R&D, production, and supply, and allowing global collaboration and an improvement in the working of the employees, by providing mobile office and knowledge portals that enhance the communication and decision-making processes. Three main goals can thus be seen: increasing operation efficiency through a manufacturing system, increasing process efficiency through application platforms that integrate the activities (R&D, supply chain, finance, etc.), and increasing employees' efficiency through mobile office, enterprise portal, and knowledge management. Studies carried out by Frost & Sullivan pointed out how Enterprises that integrate ICT in their company, shifting in the direction of a process-based organization, can increase the accuracy of the inventory information to up to 99%, reduce the procurement lead time to up to 50%, reduce the number of defects to up to 95% and have an increased customer satisfaction.

The Enterprise business focuses on three layers of activities: the service layer, the software layer and the infrastructure layer.

3.2.1 The service layer

The service layer's goal is to provide ROADS experiences to the employees by offering a service that is Real-time, On-demand, All-online, Do-it-yourself, Social. Which means connecting personnel through instant messaging, conferencing options and collaboration access points that allow to access platforms and services, connecting the employees to knowledge, documents and data in order to reduce the amount of time and costs required to connect to an expert or wait for a professional to provide a solution, and connecting the office devices with one another.

The services that can be offered involve different business areas, such as:

- Public safety, which aims at creating solutions that integrate different facilities and technologies to build safer cities. This includes communication platforms to enable a smoother interaction between different systems and to share in real-time the progress of the situation. In this way, real-time, cross-departmental collaboration can be performed.
- Energy, by developing a high-speed production network that support smart grids and reduces the electric losses.
- Education, creating platforms that facilitate the sharing of knowledge and the education in third-world countries.
- Automotive, by providing both internal platforms that increase the performance of the employees and the coordination of the processes, and by participating in the development of the services to increase the user experience in the car.

3.2.2 The software

The Software layer aims at creating a platform that supports both production IT and office IT; which means improving the efficiency of the business flows and the efficiency of people. The package offered normally features backbone unity, allowing the integration of various pieces of network that are interconnected, and flexible ends, so a solution that can fit different applications. The software has to be reliable, recoverable and with a high-performance. The latter is ensured by the backbone and flexible ends which allow to have different packages interconnected. Which means that one platform will normally focus on the product development, facilitating the product planning and development, one on the finance process, looking at the opportunities, the milestones and the billing phases, and one on the issues resolution to support the internal and external complaints.

High importance is given to the security of the network; in fact, it is of extreme importance for a company that when an employee accesses tools connected with the business, the connection is protected and data is not lost. Issues have thus to be solved before they become a major problem, and for this reason data is collected in real time and automatic systems run troubleshooting.

3.2.3 The infrastructure layer

The Infrastructure layer includes the production of Hardware (servers, storage, etc.), networks (data center networks, WANs, campus networks, etc.), and Data Centers (enterprise data centers, regional data centers, server rooms, etc.).

The hardware can be of different types depending on the scenarios; while internet-businesses will require the use of Big Data with super large DCs and massive data storages, other companies may want to focus on the integration of different architectures, requiring thus an all-in-one DC, with a local data center.

The Network solution, ***Figure 17***, covers three aspects: interconnecting devices within a data center, supporting network access in a campus and interconnecting the data center, the campus, outside vendors and the internet. It is of extreme importance that the data center is stable, as a network fault can have a huge impact on the business, and with a low latency.

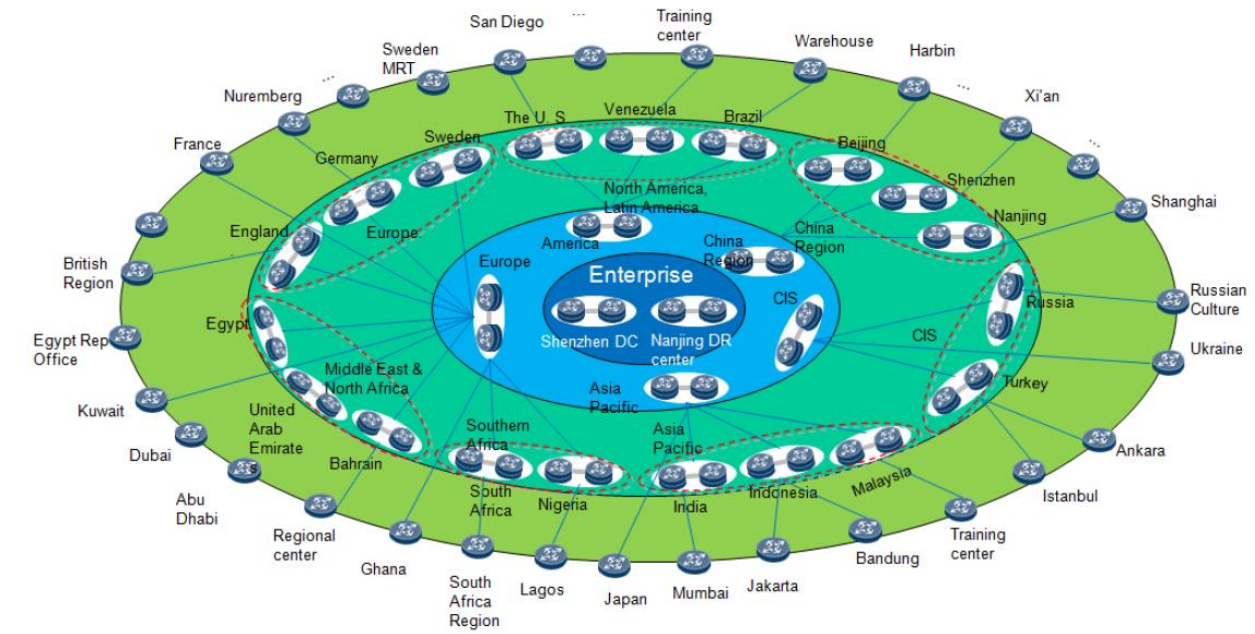


Figure 18 - Telecom Network Solution

In the Network a lot of space is also being given to Cloud computing, with models that are a mix of a private cloud and a public cloud to ensure that the solution has a balance of scalability, offered by the public cloud, and security, offered by the private cloud, as well as a flexible architecture that can meet the requirements of the customer. The differences between the private and public clouds is that while the private clouds are built on self-owned platforms and therefore are more secure and customizable to the requirements of the owner making the costs higher since the whole infrastructure is owned by the company, the public ones are based on large-scale infrastructure that is leased to the public, which means that the solution is be quicker and more flexible and the costs are of a "pay-as-you-use" type.

Data Centers are equipment rooms that include the software and hardware and other matching devices. Data Centers can be either small equipment rooms managing the information of a part of a company, Enterprise data centers, which handle major offices, Regional Data centers, or distributed cloud Data centers. While in the past enterprises required only office automation support and global networks that allowed a standard IT infrastructure with isolated DCs, now large-scaled Cloud Data centers that support Big Data and IoT are more and more requested. Quest for a cloud-based, flexible infrastructure that supports self-healing and that enables global access without performance problems.

A successful company will focus on giving structures and processes, to increase the clarity of the process structure and to easily recognize opportunities and treats, correct organization, to pursue the company's strategy, and correct support and tools for decision making. Formal structures of processes are used to give clarity and a sequence that is visible and understandable by all the team members; in fact, having a roadmap with the guiding path and the decision points facilitates the implementation of the project. At the same time, a defined and detailed organizational structure that defines the responsible person for each task ensures a high coordination. Lastly, correct tools and ICT systems support the project facilitating the tasks, reducing the number of mistakes and increasing the coordination.

3.3. Process groups

If we consider the different type of business groups presented, each one has a different process, and even if we go into one category, different projects will have slightly different processes as well. Describing in detail each type would add confusing information to the reader, misleading from the point of the work, which is understanding how project management works in the telecommunications industry. Therefore, it was chosen to describe the process groups only of the first type, the network implementation business group, being it the most general and complete one. In fact, if we look at the lifecycle of the projects in the industry, ***Figure 19***: the network rollout will follow the complete process, the enterprise business will mainly focus on the central stage, especially on the software development part of the process, and on the final stages with the maintenance, while the hardware and infrastructure design will be provided only once. Moreover, if we look at the planning of the Enterprise business, which is the most different phase, the architecture design follows the same process of the network expansion even though the information that is processed is different. In fact, while the Network looks at the data traffic in an urban area and analyzes how the capacity and connection could be improved, the enterprise architecture looks at the strategy of an enterprise to understand what the pain points are and develops a network solution that fits the requirements. The different between the two business units is bigger when looking at the organizational structure and at the way the relationship with the client is handled, reason why in the organizational part both of the business will be again presented.

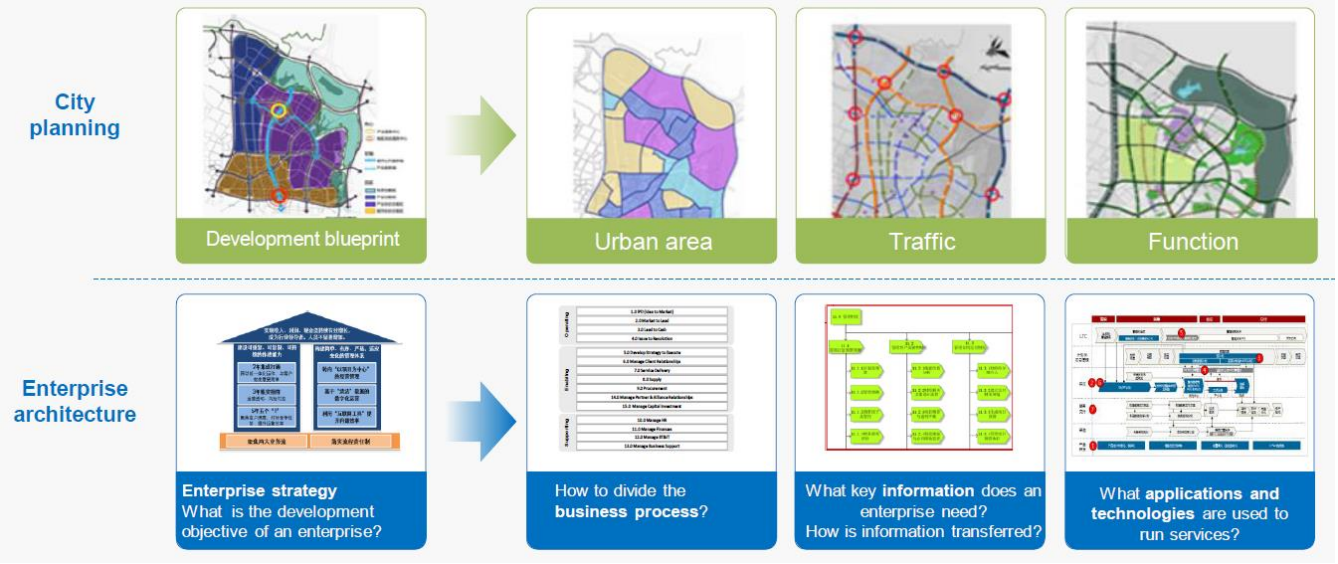


Figure 19 - Project Lifecycle of the Carrier and Enterprise Business

As already described, the Network implementation business group, aims at developing a Network infrastructure that follows the requirements of the customer in terms of coverage and capacity. Looking at the rollout of the network implementation, presented in ***Figure 20***, the project starts with the assignment from the customer and ends with its acceptance. To coordinate the activities, the rollout is defined by two Processes that are parallelized. The Project Management Process (PMP), which is identified by the processes presented in Chapter 2.2, with some differences to make it fit to the business model. And the Service Delivery Process (SDP), which works on the design of the solution and on its integration to the existing network.

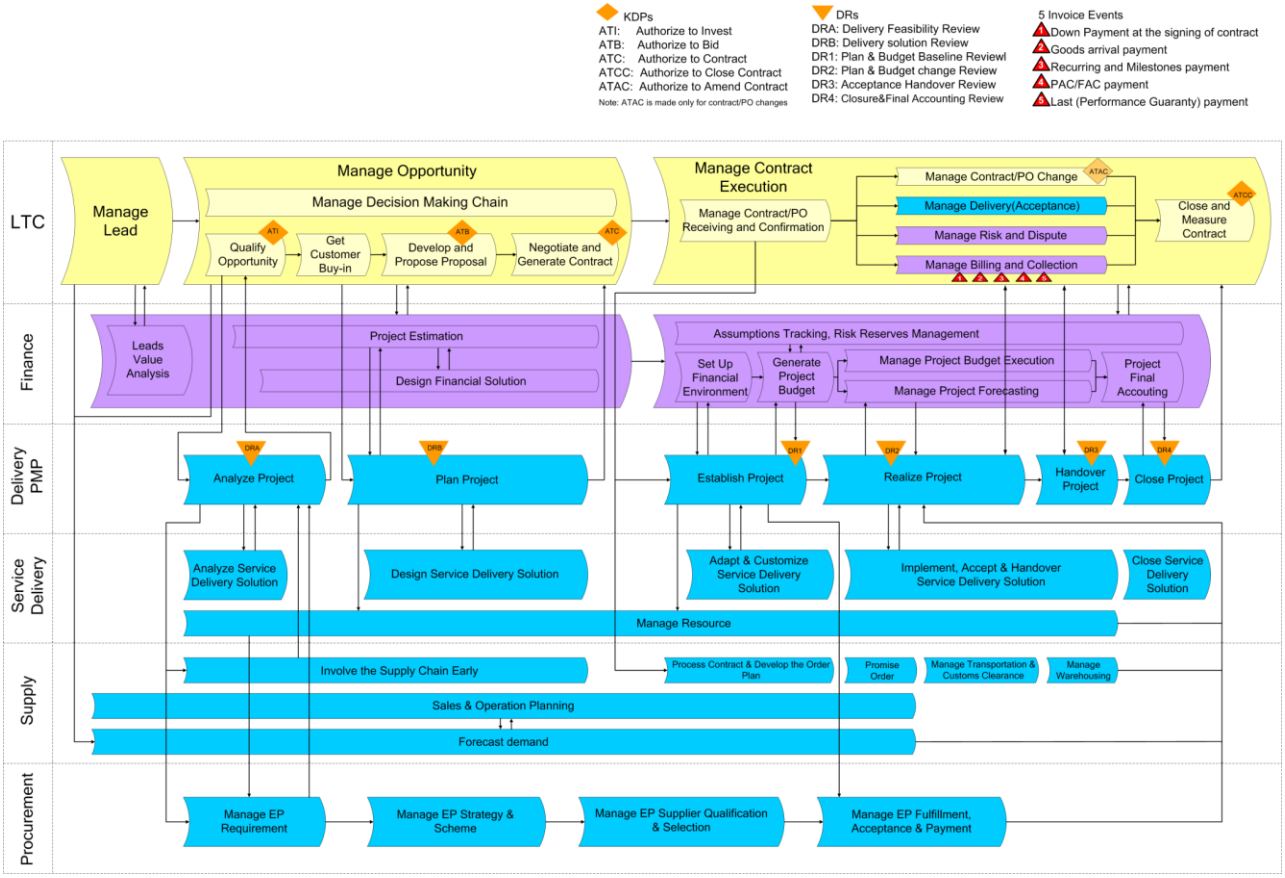


Figure 20 - Network Implementation project rollout

The fact that the two processes run in parallel means that a constant integration is required. This is achieved by clearly defining the delivery scope and responsibilities and developing a clear documentation that can be managed by all the parties. This includes the feasibility study, which supports the implementation of the project, a high-level delivery solution, to support the project estimation and master plan, a low-level delivery solution, to support the budgeting and implementation and a detailed delivery solution to guide the implementation. All these elements help supporting a contract-based delivery, which ensures that the service scope is well defined in the early phases in order to avoid delivery beyond the contract scope. Of course, an accurate plan will also be necessary, together with a precise risk and quality analysis, otherwise problems might occur during the execution or also when the project is closed.

Looking at the theory behind the Project Management, one of the most important factors to successfully deliver projects on a global scale it is to have a standard uniform project management process that is known and understood by all the members of the team. In the business analyzed, the delivery PMP consists of six phases: Project Analysis, Project Planning, Project Establishment, Project Execution, Project Handover, and Project Closure.

3.3.1. Project Analysis

The **Analysis Phase** is a preparation phase that happens before the project starts; here the opportunities are analyzed on a financial, technical and organizational perspective to evaluate their feasibility and to understand if the customer requirements meet the corporate business direction and strategy. If we consider the information presented in the introduction, this phase corresponds to the preparation of the Portfolio, where the projects are prioritized based on their feasibility and alignment to the corporate strategy.

The Analysis can either start with an Assignment specification received by the customer or by a strategic planning created by the Vendor to present to the customer where its weak points are. If the Vendor makes the first move, a strategic planning is developed, providing a diagnosis of the problem and identifying the customer needs by developing a strategic solution (through a value map evolution over a 3 to 5 years' time) that underlines how the customer position could be improved. The value map is a heat map, which represents the geographical distribution of data through a color scheme that facilitates the visual understanding. In this case the coverage, defined as the strength of the signal of the provider, is recorded over an area showing an output on a scale from green to red, representing the intensity of the coverage. Through the value map it is thus possible to identify the customer's needs and where the demand is high to provide a solution that could improve the capacity and coverage of the customer and thus improve its position in the market. An example of a coverage simulation is provided in ***Figure 21***.

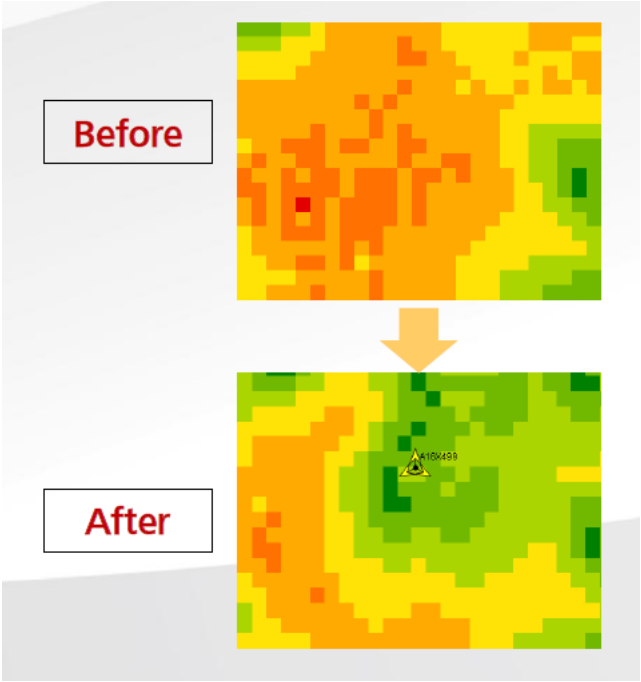


Figure 21 - Value map for signal coverage

The Representative Office is responsible of this task by providing both the value map and a SWOT analysis to see if the needs of the customer, defined in the value map, meet the internal strengths and values and help already identifying the risks of the business, which tend to be connected to the weaknesses of the company. On this matter, it is important to understand the assumptions, which means analyzing the external environment, such as local social and cultural

conditions, interest rates, changes in technology, government policies, as well as the internal environment, such as the delivery capability and the network technical analysis. At the same time, through the treats and a competitors' analysis, the Representative Office understands if the company can face problems due to a competitor having an advantage in the area due to a better relationship with the customer. In fact, in the business, the main customers have several Vendors; for example, in Germany, Vodafone benefits from services coming both from Huawei and Ericsson, using the first Vendor in the East and North regions and the second in the South and West. For a Vendor it could thus be very hard to take over the region of another Vendor, unless a big improvement is made in the technology before the competitor has it ready for the market.

Once the customer has received the documentation it will decide if the analysis has a good impact for the company and therefore if an Assignment Specification will be provided. As mentioned, the customer can also provide an assignment specification without having to wait for a strategic planning if some necessities are internally identified. With the Assignment Specification it is possible to start the feasibility analysis, by assuring that all parties are involved in the process (procurement, supply chain, service and technical solution offices) to make sure that the opportunity is analyzed from all the perspectives. A properly done analysis will allow to understand the benefits of the business and the project costs, facilitating then the contractual phase. A delivery Project manager (DPM) is thus appointed to coordinate the team to identity the basic conditions of the project from a solution point of view, to a financial by considering the terms of transaction and payment, to a quality acceptance analysis, and taking into consideration also the regulations and laws. In this stage, known as the construction planning, it is important to understand what the key issues that will be faced in the environment are, how to solve them and what the support needed is, to understand which type of investment will be required based on the solution chosen.

To have a successful project portfolio selection two conditions must be met:

- Strategic clarity of the project in order to align it with the organizational strategy. In the case analyzed, since the projects tend to be similar and with small increments from the previous solution, meeting the strategy is normally not an issue.
- Operational clarity has to be provided by highlighting the benefits that the project will bring to the company, the risks that will be faced and the number of resources expected. This second point is of higher interest, especially considering that risk management is a major theme in this type of projects.

To qualify the opportunity on a financial point of view, the responsibility goes to the Steering Committee, an entity that will be presented in Chapter 3.4.1.1, that has to determine the reservation price, which represents the lowest price at which the seller is willing to sell its good or service. At this extent, the Steering Committee is responsible of determining the BATNA (Best alternative to a negotiated agreement) that is the most advantageous alternative if the negotiation fails. If a good BATNA is developed it is possible to know what the alternatives to the deal are and therefore prevent the sales team from accepting terms that are unfavorable to the company. Having a good BATNA increases the negotiation power as the sales team is able to push the other side knowing in advance what the internal limit is. Through this analysis the Steering Committee will as well authorize the budget for the pre-sales team.

With all these information, the Business Group is then able to identify if the solution that will be developed fits its Portfolio, and the project will thus be developed by continuing with the Planning phase, or if the project is of no interest for the company and therefore it should be

discarded. The project portfolio management is a phase that is often undervalued but that has a strong impact in the success of a project if it is correctly managed. In fact, through the portfolio selection, the management is able to pick the winning projects and avoid that risks are accumulated. Moreover, only by looking at all the projects the management is able to manage the synergies, adapt to the changes and understand how to share the resources between the projects without having overloaded team members.

Common problems faced in this phase are normally caused by a lack of experience in the field, failure to conduct pre-investment activities and to have the right delivery decision point in terms of time. Especially the second and third point can be solved by having a great cooperation within the organization, ensuring that all parties involved provide timely information about their requirements for the project. A successful output will provide a solution that balances the sales strategy and the delivery and procurement strategy minimizing the risks.

3.3.2 Project Planning

Once the Project Analysis has been done and the Business group has decided that it is worth to proceed with the project, the planning begins. The **Project planning** aims at giving a realistic estimate of time and cost of a project, taking into consideration the risks that might be faced, to propose a deliverable solution to the Customer. The reason behind the importance of the planning phase is that only through a formal outlining of the project it is possible to minimize the uncertainties and risks of the outcome and therefore meet the requests of the customer making the project a profitable one.

The Project Planning starts when the Request for Proposal (RFP) is received from the customer. In fact, once the carrier presents the document with a detailed description of the solution they want to implement and the network parameters that aim to achieve, the bidding team can start to analyze the requirements presented and the risks associated to implement a correct strategy. Based on the information gathered from the RFP, a conceptual design and a preliminary budget, by performing an investment analysis and cost efficiency evaluation, are developed. All these pre-optimization tasks are done to ensure that the performance of the network will guarantee the KPIs established with the customer.

The RFP is a document that solicits the proposals of the Vendors to take on the project of a Customer. In the case being analyzed, the bid is of a private type so there are not strict law rules and timing applied, but the winner will be chosen on a competitive basis. Being the contract mostly of a turnkey type, where the design, construction financing and physical construction will be all in the hands of the Vendor, the proposal process will be expensive and time-consuming to make sure that the project will fit the company both on a financial and quality point of view. This is also one of the reasons why the company has normally already worked on a feasibility study in close contact with the customer in the Analysis phase.

The project planning is based on developing an efficient and winning strategy that will allow to win the contract with positive conditions. To assure this result four points are of extreme importance: having a good overall perspective, setting upper limits, developing an implementation plan closely with the customer and developing a pricing strategy based on the market price. The first point refers to setting conditions and clauses to prevent problems during the project rollout, while the second involves defining the upper limit, up to which the responsibility of exceeding costs are on the Vendor. The implementation, on the other hand, must involve the customer to share

the risks of delays in the project; in fact, once the customer is involved in the scheduling plan, it is his responsibility to clarify inconsistencies. Lastly, the pricing strategy is important to assure a return on the project investments, identifying the optimal pricing method (which normally will be of a lump sum). Regarding this last point, the Vendor does not have a high bargain power over the pricing, unless a very new technology is being presented. For example, all the projects that involved the expansion of the LTE had a price/site built estimated based on the LTE sites that were already done.

Since the cost of a site is fixed and the business is based on revenue generation from subscribers use, which means that the more a node is used the more revenue it will generate without increasing the costs, it is extremely important to have a correct planning of where the network expansion will happen, as a mediocre site selection could bring to a losses in terms of user base and problems in the launch if the positioning of the antennas is not optimal. To set up a correct project environment, the first stage is to understand the customer's commercial strategy, which includes its competitive position, market plans, trends and high-level objectives, to develop knowledge on the management plan. In this way, a proper Site Selection, aiming at measuring the needs of a new project against the merits of potential locations, can be developed. In the Site Selection, market survey departments, using a Value Map, provide inputs with the potential subscribers, the density of the users, the traffic flow, the major junctions, etc. At the same time, the value map is compared with the competition map, to understand where the coverage is offered by a competitor and where the customer could increase its efficiency. The reason why these two maps are used is that the customer aims at a network without gaps and with a capacity that fits the number of customers that require the service in the area as gaps during the use of a mobile phone is what decreases the most the customer satisfaction, leading the customer to change provider. The number of sites per city will then be based on the coverage map, which is then used to understand how much revenue the installation of the site could generate, keeping in mind that the cost of a site is fixed (varying only based on the amount of civil works required) and that the profit will be based on the user base of the site. When defining the sites to be implemented, it is important to include the Project Team as all the risks and challenges that could be faced during the rollout have to be identified to decide if a site is worth building or not.

To analyze the RFP and identify the requirements and risks of the proposal a sales team, responsible of defining the project scope by following certain assumptions, is appointed. The output of the analysis is the aggregation of two solutions: the Delivery Project Management Solution and the Service Delivery Solution. The first aims at describing how to manage the delivery, by defining the project objective and scope, as well as how it is executed, monitored and controlled during the Delivery Stage. To achieve this goal different figures will be involved, of which one of the most important is the Delivery Project Manager, who is responsible of providing a Scope of Work (SOW) which contains the main milestones and the deliverables expected to be provided (e.g. SWAP, LTE, etc.) taking into consideration the project boundaries that define the scope and acceptance criteria. The scope that is provided includes the main delivery activities and the key technologies and requirements that will characterize the output. While the Service Delivery Solution describes through a Roadmap how to execute the delivery, including the description of different scenarios, of the processes involved, of the responsibility matrix and the acceptance criteria. Concerning this second solution, two activities are of importance: providing a deployment plan and defining a launch strategy. The first aims at defining the main activities required to succeed in the implementation, and the key requirements and constraints that impact the deployment environment; the second, provides a plan to assure that the launch of the site is

successful, both in terms of launch time window and rollout mechanisms. To achieve a good coordination within the two solutions a collaboration of the PMP and SDP teams is required. In fact, the PMP defines the project objective and scope, as well as provides a description of the implementation and monitoring phases, with a plan that considers all the main constraints presented in the introduction chapter (time, scope, cost, resource, quality, risk). While the SDP provides a roadmap on how to deploy the project to the customer, including the scenarios analysis, the responsibility matrix and the acceptance criteria.

3.3.2.1 High-level Design

The design that is generated in this phase is of a high-level type (HLD), which means that it will cover the overall architecture design and the relationship between the modules, describing it in a non-technical way as it has to be understandable also by administrators. Other than an overview of the whole network, including network architecture, system interface, capacity and reliability, the design must include the preliminary milestones that will characterize the master plan and the cost baseline resulting from cost estimations coming from each business unit involved in the project. Here is where the difference between the types of projects will be greater: while a network expansion only requires minor civil works, which are the biggest part of the cost of a site, a new installation will be more expensive.

To provide a good HLD, a collaboration between the Vendor and the customer team is required. In fact, the customer has to clarify the requirements of the network and participate in the reviews to ensure that the design provided fulfills the scope requirements. Moreover, since the live network will then be owned by the customer, it is important that the design that will be developed fits the organizational capabilities of the customer. Therefore, once the customer has provided a service proposal with the requirements of the overall framework and a background and delivery objectives of the project, the delivery team starts its analysis of the Scope of Work (SOW) to identify if there are requests coming from the customer that are out of the scope, and thus require a modification of the contract if necessary. Once the SOW is correctly defined the Technical Director (TD) can draft the infrastructure deployment strategy, which includes the estimated deployment period and plan, the requirements of the locations that will be involved in the implementation in terms of room space and environmental conditions, the main activities and responsible parties of each rollout phase.

A great design will have the optimal balance between cost, quality, and schedule, will provide the quality requirements to support the implementation team, and will underline the major delivery risks. An example of a High-Level design is presented in ***Figure 22***.

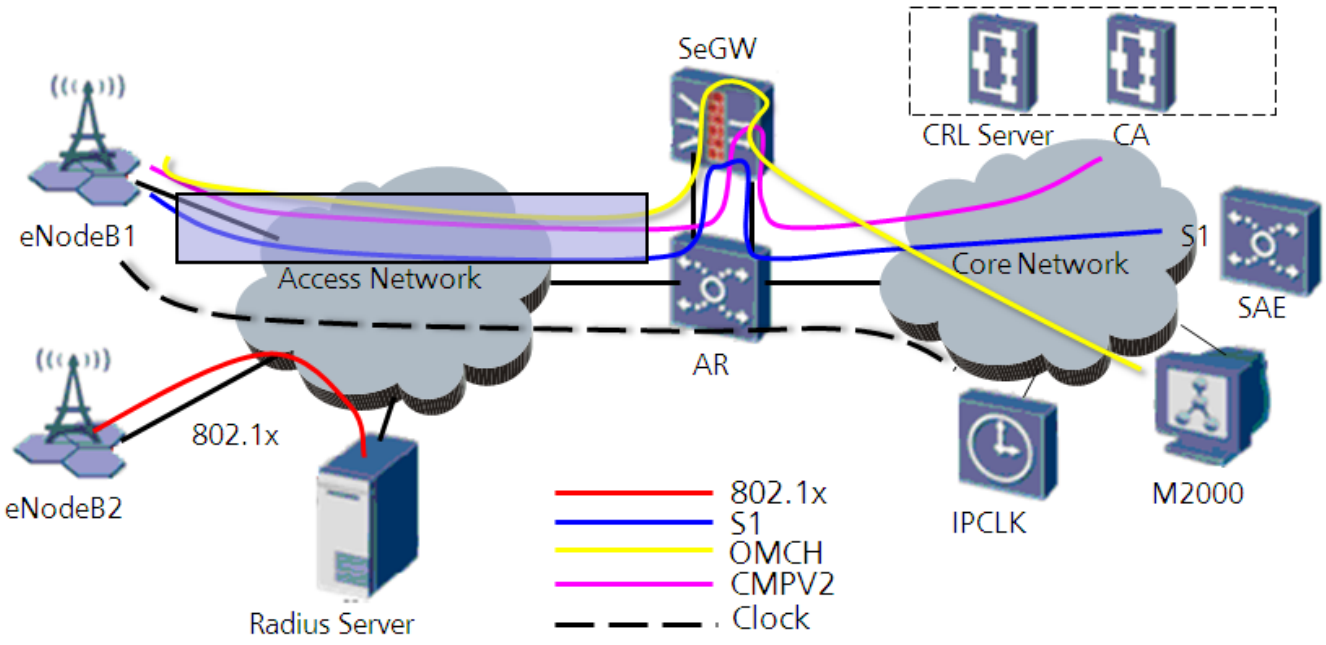


Figure 22 - Network High-Level Design (HLD)

Once the delivery solution is ready, before being submitted to the customer, it is reviewed by the PMO that analyses if there could be changes that could directly affect the cost of the services, risk and profitability; in this case, most of the times a meeting for bid clarification will be requested to the customer. Only when the delivery plan has been confirmed by all parties, the documentation will be sent to the customer, together with a presentation of the activities required. Since the execution of the project will be of a cyclical type, the delivery solution may be reviewed multiple times if major changes are made to the solution. If the changes are minor only an approval by the PMO will be necessary, while if the change has a higher impact, the approval of the Regional Office will be required.

3.3.2.2 Sales team

To have a fast delivery solution preparation, the company must have a set of core resources that can focus on the bidding phase, these resources are known as the steering committee. The steering committee must pay attention to customer requirements, pushing the customer cooperation and maintaining a good relationship with it. The Network and Technology planning team, headed by the technical director (TD), has to focus on planning and designing a solution that supports the acceptance and quality requirements. The Regional Teams have to start preparing documentation for the upcoming site design and the Supply chain department has to start preparing a fast and good delivery plan.

The figures involved in the High-level design are the delivery project manager (DPM), the procurement project manager (PPM), the Supply chain management (SCM), the technical director

(TD), the quality director (DQA) and the contract manager (CM). The DPM is responsible of developing the preliminary milestone plan and master plan, including in it the major delivery risks. The SCM responsible of providing the Lead Times for the orders, a design of the delivery plan and of the warehouse, identifying the risks connected to it and the requirements for the transportation. The Quality team, on the other hand, focuses on the requirements and on the metrics that will be used to evaluate the delivery solution. Lastly the TD will be responsible of the network technical overview. Each department representative of the sales team, once the major milestones are defined, has to provide his input for the delivery high-level solution, a cost estimation, including the delivery assumptions, the major risks and their assessment to include into the baseline cost. The finance controller summarizes then the service cost estimation results of the business units to provide the project service cost estimation.

It is very important that during the contract negotiation the customer is highly involved; in fact, only through clarification of the delivery requirements and scope the right assumptions can be made and the correct risks identified, improving the contract deliverability of the solution. And, considering that the industry analyzed is mainly made of the big players (Huawei, Ericsson, Cisco, and Nokia), the winner of the bid will mainly be connected to who will be able to offer, yes, the most advanced technical solution, but also the one that will fit best the requests of the customer, with the lowest price possible. At the same time, it is important to integrate the customer's plan and requirements in order to meet the delivery capability of the company (supply, resources, etc). For this reason, the organizational structure defined has parallel roles both on the Vendor and on the Customer side. At a strategic level the interaction will be between the two Steering Committees and Sponsors, and in some special cases between the CEOs. At a tactical level the resources involved will be the PMOs and the Project Directors (PD). While at an Operational Level the interaction will be between the Project Managers.

3.3.2.3 Project Supply

Based on the customer expectation of the project schedule, the HLD is integrated with the scheduling dependencies and assumptions to develop a milestone plan that defines the Master Plan, which will be presented in Chapter 3.5.2. To have good estimations of the activities of the implementation is of extreme importance to define in the early stages how to handle the activities that are more time consuming in the project. In the industry analyzed, in these terms, two of the most important business units are the logistics and procurement. In fact, these sub-processes are both time consuming and with the highest risk (up to 77% of the problems occur here) as, on one hand, after the bidding phase the Customer does not authorize to designate a new supplier for the components that are being purchased, on the other, due to lead times, it is not possible to order hardware once this phase is concluded. Which means that a wrong selection of the partner and a wrong forecast of the hardware needed will influence the whole project.

On the procurement side, when choosing a supplier, the target is to keep the costs low but maintaining the quality and timeliness high. The cost of a supplier is called Total Cost of Ownership (TCO) and includes the price of the supplier, the handover cost, the investment cost, and the rectification cost. To choose the best supplier, depending on the amount of money available, the Vendor will then choose to proceed either with a Bid Invitation or with a Negotiation and price comparison. However, given the nature of the business, Vendors have a Portfolio of subcontractors with their performance in past projects and choose normally between those suppliers. The reason

behind this choice is that the qualification quality of the supplier highly impacts the quality of the delivery and Vendors rely thus on suppliers that have a good long-term relationship with them. The evaluation of the subcontractors is based on six points;

1) Technology: the technical qualification of the subcontractor is analyzed through data provided by past collaboration and by market researches. In this case, the stability of the technology and the skill level of the resources are identified.
2) Quality: design solution provided is submitted accurately and in a detailed way, meeting the requirements of the Vendor.
3) Response: the response time to issues and the flexibility of the solution provided are analyzed. In fact, it is important that subcontractors can respond on time to all kind of issues, including modifications in the delivery requirements, peaks on the demand and change requests.
4) Delivery: it is important that the subcontractors submit the documentation on time, accurately and with complete information to reduce the delays due to poor documentation.
5) Cost: in this term two types of costs are taken into consideration, on one hand the normal costs of the service provided, on the second hand the cast changes due to changes in the delivery solution.
6) Environment, Health and Safety (EHS): the Vendor has to ensure that the subcontractor in engaged in EHS management and complies with the requirement of the Vendor itself and of the local law.

Depending on the level of investment needed, the decision on the supplier will have to be approved only by the PMO and the PPM, or, in special cases, also by the HQ.

For what concerns the internal supply chain, it takes overall from 8 to 10 weeks to manufacture the hardware and transport it to the central warehouse, plus 2 to 4 weeks to transport it from the central warehouse to the local warehouse (***Figure 23***) if the forecast is known, or 60 days if the forecast is unknown; and considering that a Vendor has several sites being built in several states across several continents, the internal policy establishes that the hardware manufacturing is defined in the Project Planning phase of a project and that the production will be based on this forecast. If the number of hardware requested exceeds the production, the only solution for the delivery team is thus to coordinate with other projects to understand who has exceeding material available. Therefore a strong collaboration with the customer is required to ensure that the long-term rolling forecasts are as accurate as possible, and, if past projects show that the customer has a poor planning, normally the Vendor will add clauses to the contract that limit the changes during the rollout phase, or passes the risks responsibility to the customer itself.

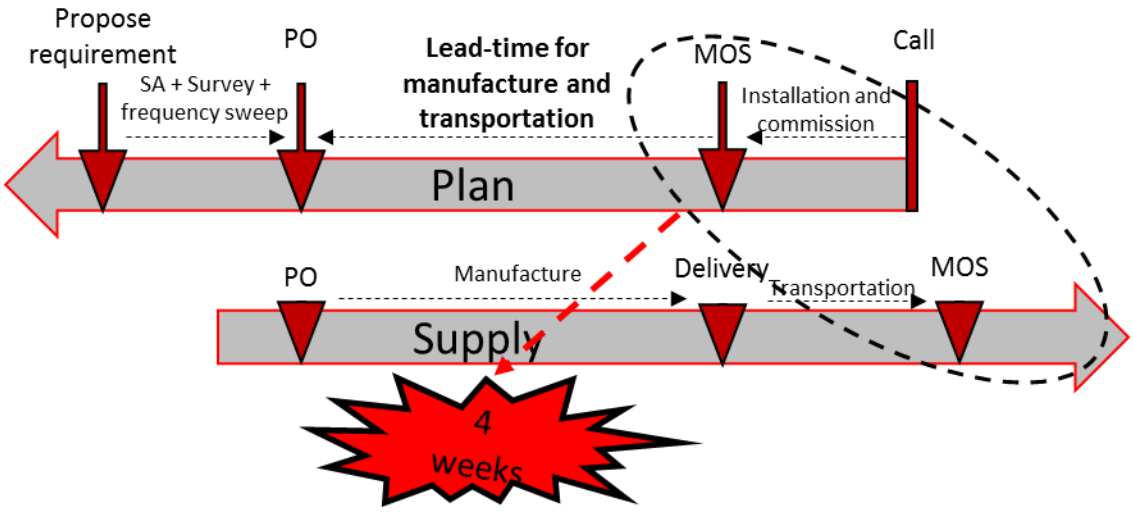


Figure 23 - Material delivery planning

To ensure a good supply solution, it is important to define the environment in which the delivery takes place. In fact, the geographical surroundings of the warehouses and of the sites, impact the time requested to deliver the material and therefore should be included both when defining the risks and when analyzing how much Lead-Time (LT) is requested to deliver the site on time. At the same time, it is important to have done a good analysis of the customer and its commercial strategy to understand if it will press to accelerate the delivery of the output by improving the delivery and logistics solution. If, for example, the sales team identifies a customer with a high pressure on a fast delivery, the supply plan developed will include a high delivery of material, and thus a bigger space in the warehouse, to store more goods.

The delivery plan, ***Figure 24***, is based on the type of material requested, on the type of site being built and on the supply path requested. Three different solutions can then be provided:

- Delivery to the local warehouse where the main equipment is aggregated and then from there distribute the items based on the rollout request. If the material is delivered to the central warehouse it is important to prepare the main equipment according to the installation plan and to complete the configurations to clear the BOQ to accelerate the fast-track delivery in case it is necessary. For this reason, the supply chain team has to put a great effort into the organization of the warehouse and the granularity of the packages, to ensure that all the requested material is easy to reach.
- Delivery directly to the site and complete aggregation at destination. This solution is normally required when the sites have to be built from zero and a lot of partner material (such as towers and shelters) as well as low value material are required. All these materials are provided by the subcontractor as direct purchase and therefore transferred from the customer warehouse directly to the site. Moreover, also some material coming from the supply center can be delivered directly to site when the delivery to the central warehouse and then to site would generate a transportation time bigger than the LT. Therefore, delivering directly to the site allows to keep the rollout on time.
- Cross-docking, to allow the partners and subcontractors to pick up the material and bring it to their own warehouse for temporary storage. In this way, the implementation can be more flexible and adaptable to changed. However, it is important that the material delivered to

the partner through X-Docking is constantly monitored to ensure that it is returned to the central warehouse when it is not needed in the short time (normally, in the company analyzed, a material cannot be stored at a partner's warehouse for more than 14 days).

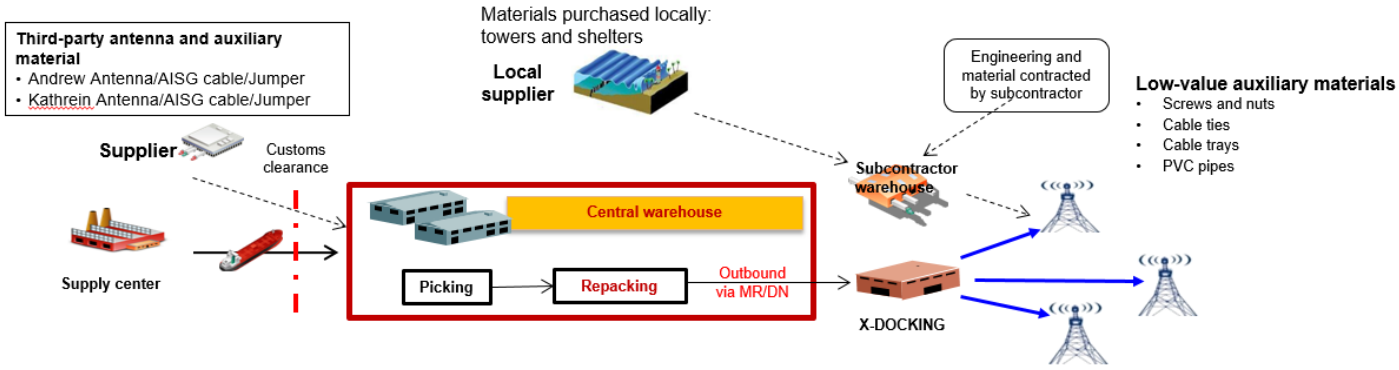


Figure 24 - Delivery solution plan: to warehouse, to partner, X-docking

3.3.2.4 Budget Estimation

The industry of the telecoms grew a lot in the past decade and, with its stabilization, the competition is going in a direction of cost reduction. Reason why the budgeting phase is getting more and more important. To control costs from the beginning is required to clearly define the business and cost model at the project preparation stage and to prepare a good budget estimation during the bidding phase. In fact, the solution design is used to define the pre-investment that will be necessary for the development of the project and, especially, the size of the rollout is not estimated in terms of number of sites implemented but budget consumed. To support decision making, estimations of the headcount, material costs, duration, and risks are made. The cost proposal contains in fact a detailed price breakdown that integrates the materials together with the costs generated by the total duration of the project and the headcounts. However, as stated from the name, this will only be a bidding budget, while the baseline that will be used to define the expected costs of the project will come when the Master Plan will be more precisely updated based on the number of sites built and on the new budget releases coming from the customer. However, the bidding budget should determine 80% of the project cost, and additional costs should come only from changes.

The costs of a project come from several sources: human resources, procurement price of subcontractors, equipment, transportation, services, period expenses, taxes, exchange rate, and capital fixed cost. The cost of the equipment is controlled by the HQ, which means that the sales team does not have any power to reduce it to reduce the bidding price. Taxes and exchange rates cannot be avoided but can only be mitigated through insurances, which increase the cost in the immediate time, but reduce the probability of having costs increases at the end of the project. The expenses that can then be managed are the remaining. Human resources can vary thanks to headcounts changes, of course having to pay attention that the headcount reduction does not provoke a delay in the project. The procurement cost, as presented in the forthcoming chapter, is reduced through a strict selection of the supplier, without however forgetting that the quality also has a high importance for the business. The transportation can be managed by supply chain to have more material being transported at the same time. Service costs are reduced by decreasing the

installation and maintenance, especially through a high focus on the quality that reduces the number of technicians that have to go back to site and by reusing sites and expanding them, without having to build from zero. Period expenses like staff travel costs, can be reduced through contract clauses. Lastly, capital fixed costs can be mitigated through a well-managed warehouse. As it can be noted, the main factor can be influenced is the delivery cost. Which means the costs connected to the supply and the implementation.

The headcounts have to be correctly defined to ensure that all the resources needed for the project are defined on time. In fact, the price of a single site, which is standard, will include in the costs of the material and the costs of the resources. Which means that if a wrong estimation of the number of resources needed is made in the bidding phase the negative impact in the profit of the project could be very high. The number of resources needed is defined starting from the scope of the project and the skills required to fulfill the objective, integrating it also with the outsourced resources required and the time required from each resource.

As mentioned, it is important to note that during the planning phase the pricing method does not define the final total price of the project, but the price per site. In fact, over the project execution the amount of sites that are built can vary based on requests coming from the Customer. If we look at the cost of a site, it is defined as:

$$Cost = SE + TI + CW + HW$$

Where SE is the Site Engineering, TI the technical installation, CW the civil works and HW the Hardware (and software). All the components will be described in the following pages of the thesis.

As mentioned several times, the cost of a site can however vary depending on the type of project that is being carried. Mostly two types of costs can be identified: sites where the whole project is done by the Vendor, which will include all the cost components presented above, and sites where only the technical installation of the hardware is done without requiring any site engineering or civil works. Of course, the total cost of the first type will be more expensive then the second; however, in an individual point of view it will be higher in the second one. In fact, the headcounts are based on the overall project and not on the singular site; therefore, the cost of an expansion will have yes only the TI and HW costs, but these will still be based on the same amount of team members.

As most of the construction projects, taking in consideration that several types of projects exist, the contract in this industry will mostly be Turnkeys or traditional design-build-bid with price based on a Lump-sum type. In a Turnkey contract, the contractor takes responsibility for the design, the construction and the short-term financing. On the other hand, in the design-build-bid contract, the contractor is only responsible of the construction and the activities connected to it (thus procurement and site management, but in this industry only connected to the hardware construction), while the design and the civil works are made by the owner, or most of the times by another company. The Lump-sum payment is thus due at the end of the construction, with only small milestone payments during the implementation of the project. Which means that the bid will not be in individual prices, but the customer will submit a global price, making it a good pricing method for projects with a well-defined scope, like the ones connected to the development of a network. Since with this type of contract the risks are all on the contractors, normally a capping will be set. Which means that up to 10X% of the contract costs will be covered by the vendor, but if this 10X% is overpassed, the contractor will be able to ask an additional payment for unforeseen

contingencies. The capping model is used to manage those sites where the costs are extremely high compared to the given lump-sum; however, as contract, a maximal percentage of capped sites is allowed to avoid the abuse of this clause by the Vendor.

3.3.3 Project Establishment

The **Project Establishment** is the phase in which the project is initiated, and it starts with the contract handshake and the registration of the contract in the systems. The contract handshake, also known as the "gentleman's agreement", is an informal understanding between the two parties. It means thus that the parties agree on proceeding with the project execution, but the contract is not signed yet, which means that the Vendor can still modify part of the agreement.

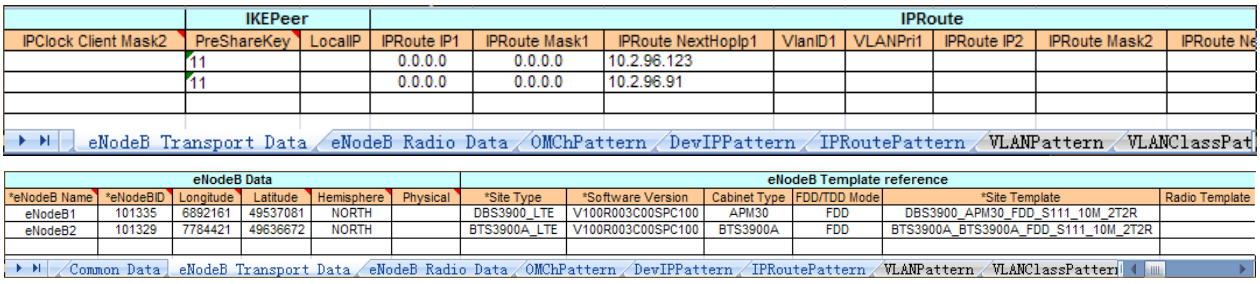
After the contract handshake and the registration of the contract in the internal system, the kick-off meeting can happen and the project team, together with the project manager, can be appointed. During the Kick-off meeting, the Project Manager makes sure that the project team, the customer and the partners/subcontractors are aligned on the Project Plan and on the Responsibility matrix before the implementation starts. This is a critical point since it happens often that a project fails due to a lack of understanding of the responsibilities of the team members. During the kick-off meeting, the interface person of each party is appointed, and the communication tools are agreed. To correctly prepare a communication plan all the stakeholders must be identified, together with their impact in the project and their participation in the project delivery. Preparing a communication plan between all the parties is important as it ensures that the project is delivered smoothly. More meetings with all the stakeholders will take place during the implementation to share reports and updates. In this phase it is also important to ensure that the departments and roles responsible for all modules are designated and presented to the customer. In fact, to ensure that the communication with the stakeholders is optimal, facilitating the cooperation, it is important that the internal resources, as well as the subcontractor's resources and the corresponding figures on the customer side are designated. In this way misalignments between the implementation plan and the availability of resources and supply are solved in a more efficient way.

At the beginning of this phase war rooms to discuss and train the team members are set up. In the war room, project teams and stakeholders are gathered to communicate and discuss the critical activities of the project. Locating the entire team in the same room facilitates direct communication, problem solving, solution identification, and sense of team commitment. In the war room team members, as well as stakeholders, can see the progress and current status of the project, visualizing the performance indicators. For a war room to effectively work, it must involve all the parties that work in the project, starting from the core 8 members of the team (presented in Chapter 3.4.1.2.2).

Since the project team is normally not involved in the bidding phase, to ensure a successful delivery of the project, the project team analyzes and reviews the contract conditions to understand if they are feasible also on their point of view. The contract handover is performed to ensure that the contract information can be fully transferred from the sales team to the fulfillment team. In this event, the fulfillment team has to analyze the solution developed by the sales team and identify its feasibility. In case of problems, the sales team should clarify the terms to then develop, together with the fulfillment team, a solution that satisfies both parties. The most important things that must be agreed are: the financial terms, the supply and procurement information, the product and solution information and the delivery conditions. The contract handover closure can happen only

once the solution responsible communicates to the customer the product and delivery solution and this latter accepts it.

In the establishment phase, the master plan is reviewed to understand if the time and budget (especially the latter), can be fulfilled. The review from the project team has to ensure that the project will be managed, performed and completed in a manner that suits both the organization's and the customer's requirements. The result of the second review is a Low-Level delivery solution (LLD), ***Figure 25***, based on the high-level solution, which includes all the documents presented in the Planning Process of the PMI describing the actual logic for each component of the system, the milestones and milestones' relationships, the attributes of the sites and an implementation template. In fact, this delivery solution will provide detail data and parameter planning used for the Node configuration and integration, including the WBS, the project plan and the Project Budget. The LLD ensures that the network resources are properly used, and the delivery risk of the engineering is reduced.



	IKEPeer		IPRoute							
IPClock Client Mask2	PreShareKey	LocalIP	IPRoute IP1	IPRoute Mask1	IPRoute NextHopIp1	VlanID1	VLANPri1	IPRoute IP2	IPRoute Mask2	IPRoute Ne
	11		0.0.0.0	0.0.0.0	10.2.96.123					
	11		0.0.0.0	0.0.0.0	10.2.96.91					

eNodeB Transport Data | eNodeB Radio Data | OMChPattern | DevIPPattern | IPRoutePattern | VLANPattern | VLANClassPat

eNodeB Data						eNodeB Template reference					
*eNodeB Name	*eNodeBID	Longitude	Latitude	Hemisphere	Physical	*Site Type	*Software Version	Cabinet Type	FDD/TDD Mode	*Site Template	Radio Template
eNodeB1	101335	6892161	49537081	NORTH		DBS3900_LTE	V100R003C00SPC100	APM30	FDD	DBS3900_APM30_FDD_S111_10M_2T2R	
eNodeB2	101329	7784421	49636672	NORTH		BTS3900A_LTE	V100R003C00SPC100	BTS3900A	FDD	BTS3900A_BTS3900A_FDD_S111_10M_2T2R	

Common Data | eNodeB Transport Data | eNodeB Radio Data | OMChPattern | DevIPPattern | IPRoutePattern | VLANPattern | VLANClassPatteri

Figure 25 - Network implementation: Low Level Design (LLD)

The reason why these activities are performed in the establishment phase and not in the planning is that all the necessary information becomes available only in this stage; in fact, while in the planning the project milestones come from the customer, these are usually very rough and once the project team is set up it can adapt the customer expectations to a feasible plan. The WBS is a major step of the project initiation, since it is the basis for the development of a responsibility matrix, of the network scheduling, of the cost estimation, of the risk analysis and of the project controlling. The WBS, ***Figure 26***, is made of different levels, of which the upper ones are normally related to the delivery scenarios and business units, while the lower ones to the procedures and work packages.

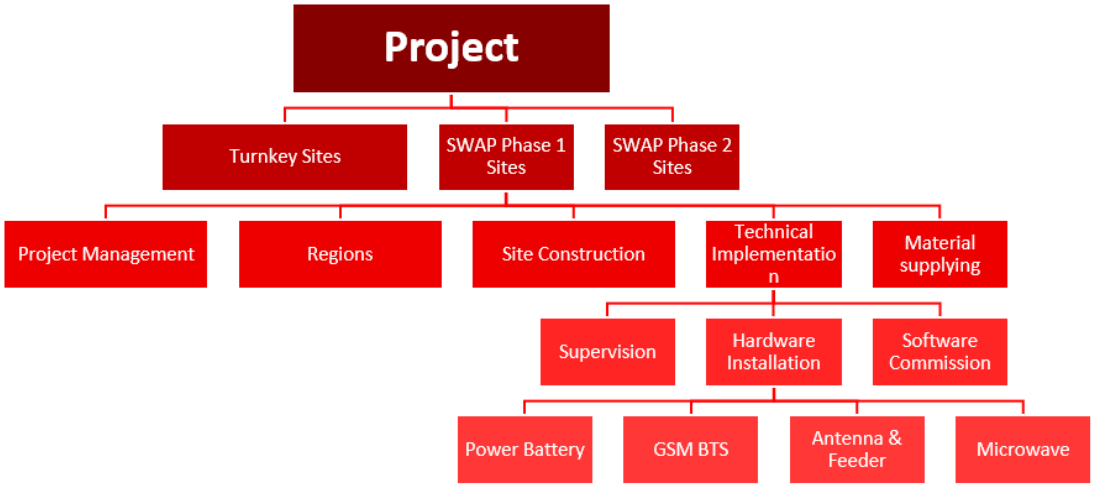


Figure 26 - Project Work Breakdown Structure

Starting from the WBS a detailed scheduling report, together with the costs associated to it, is developed. The Project manager is responsible of the Master schedule with the overall expected rollout, while the detailed scheduling is developed, yes at a project manager level, but with the input coming from the customer and with the support of the technical business units. To have a good scheduling the technique used is that the demand is scheduled backwards, while the supply is scheduled forward, ***Figure 27***. Backward scheduling is the optimal approach that results in a superior plan, however it does not work for the scheduling of the supply. In fact, while the demand of the sites can be roughly estimated since the contract signing, the amount of material needed is not. Therefore, the demand is scheduled in order to meet the due date established in the contract, minimizing the work in progress and the number of sites that stay in a not completely finished status, by setting the job scheduled to meet the result in a backward basis. While the supply, which is scheduled on a short-time basis, is scheduled forwardly, by requiring the production and delivery of material when the plan has already been made.

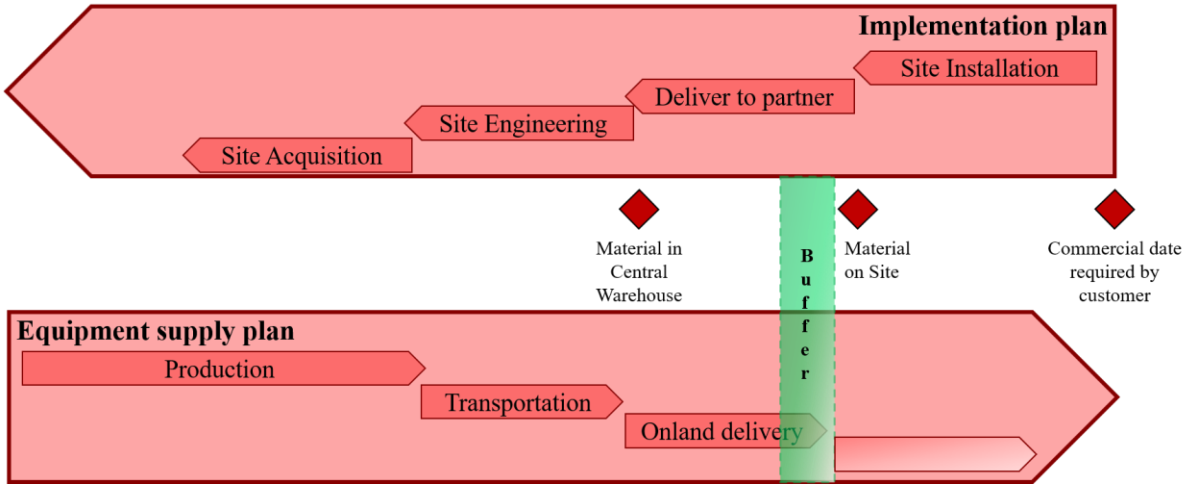


Figure 27 - Backward scheduling of demand, forward scheduling of material

Regarding the budget, the owner of the Budget review is the Project Manager (PM) who has to determine if the budget and costs estimated are correct and fit the Master Plan update, based on the LLD, by signing the project commitment letter. To have a correct evaluation, the estimation and assumptions that will lead to risks baseline costs are reviewed also by the financial team.

From this point on a cyclical process starts, which means that while the Project analysis and plan are made for an overall project, from the project establishment onwards, the phases will be repeated on sites batches. In fact, the solution presented with the Master Plan is not stable during the whole execution of the project, as the number of sites is only estimated, which means that modifications occur during the project lifecycle. Therefore, there will be continuous updates based both on the feedback coming from the customer and on the availability of the resources, in terms of employees, partners, material and finance, as well as in terms of coverage reached and new sites available.

The general process, presented in the following flowchart, ***Figure 28***, is made of four different milestones in the project Establishment phase of the PMP, and six in the project Execution:

- Project Establishment
  - Redline meeting
  - Site Survey
  - Site Design
  - Approvals
- Project Execution
  - Civil works
  - Installation & Commissioning
  - Ready for Service
  - Technology in Service
  - Ready for Customer
  - Infrastructure acceptance

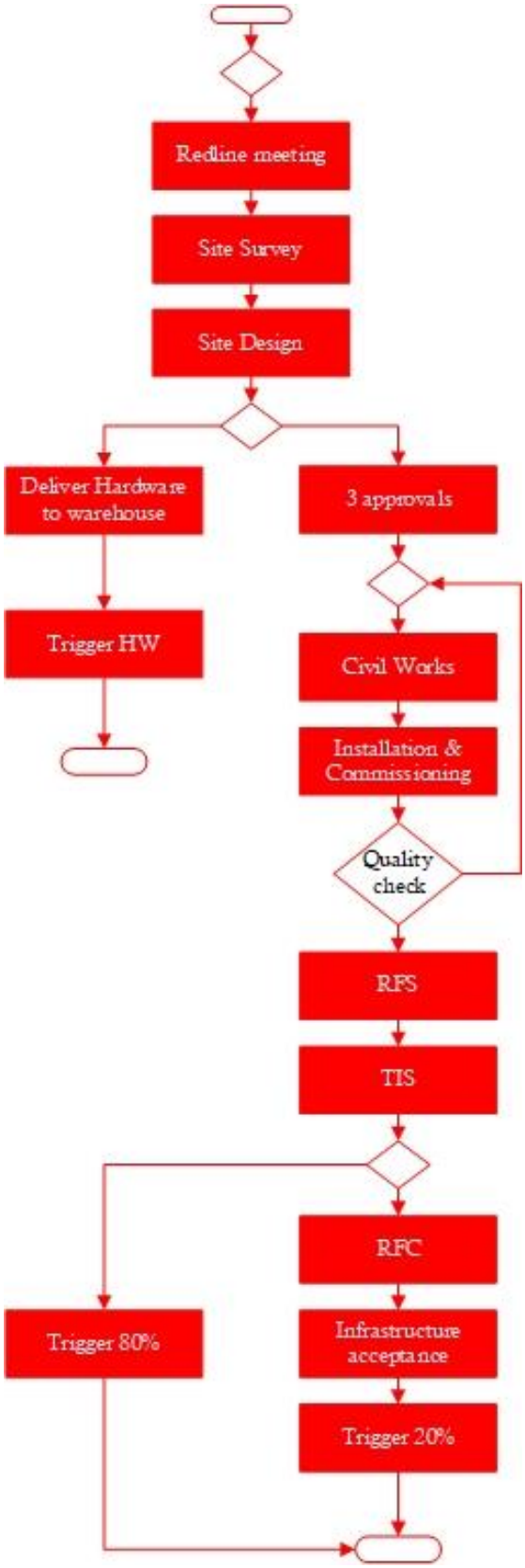


Figure 28 - Flowchart of the network implementation process

The Project Establishment is characterized by two main milestones:

- **Redline meeting**: with the high-level design developed during the Planning phase, a meeting with the customer, which happens either once per week or every two weeks, is requested to define all the details of a batch of sites and the conditions for the change management. Only with a detailed solution agreed by both parties, the Vendor will proceed with the implementation. During the Redline meeting the drawings coming from the previous phases are checked to see the best way of implementing them to keep the costs as low as possible without affecting the quality.
- **Site Engineering** (SE): The Site Engineering requires a first Purchase Order (PO) from the customer to sustain the costs of development of the drawings of the project outcome and it is made of three different checkpoints: the Site Survey, the Site Design and the Site Design Approval.

The **Site Survey** is technical and involves also the partners/subcontractors, since all the parties will go on site to verify if the solution decided in the Redline meeting is feasible in the actual environment. During this phase both parties discuss and determine the physical location, the equipment room layout, the cable wiring, the required installation materials and the specifications. It is important to analyze the environment since the efficiency of the network depends also on the position of the sites; in this matter, it is normally preferred to be close to the grid centers and in tall buildings without surrounding obstructions that could interfere the signal, as sites are mostly interlinked by microwaves that are connected through a line-of-sight (LOS). The LOS has a huge impact in the performance of the site and is therefore analyzed in detail when choosing where to locate a new site. This phase could involve contract changes since, for example, the parties could realize that the environment is not suitable or that additional costs are necessary to reinforce the structure. Building strength is a problem that occurs with a lot more frequency than expected; problems include having a basement that does not withstand the weight of the equipment, or a site that is not big enough. When the Site Survey is completed both parties must sign the report that confirms that the event took place and that the solution was agreed.

The **Site Design**, ***Figure 29***, is a document that presents all the information collected in the bidding phase together with the ones provided by the Site Survey. This document will have all the drawings with the detailed description of the environment and the construction design, statistical calculations and work instructions, description of the heating, piping, ventilation and air conditioning, the bill of quantities of the equipment that will be delivered to site and the installation plan. In particular, the document has to include the following aspects:

- Equipment room refurbishment plans according to the current situation of the equipment room;
- Determining which accessories are necessary, such as the quantities and specifications of the power supply equipment, the maintenance and operation equipment, the transmission equipment, the distribution frames, and the entire grounding plate;
- Preparing technical specification documents and requirements of various equipment to be installed according to the rack structure and anti-quake requirements;
- Determining the station, subscriber, and billing data;
- Preparing a detailed construction schedule;
- Preparing the floor plan, together with the detailed locations of the equipment and accessories;

- Preparing a detailed cable layout for deployment;
- Preparing the responsibility matrix for installation materials between the two parties.

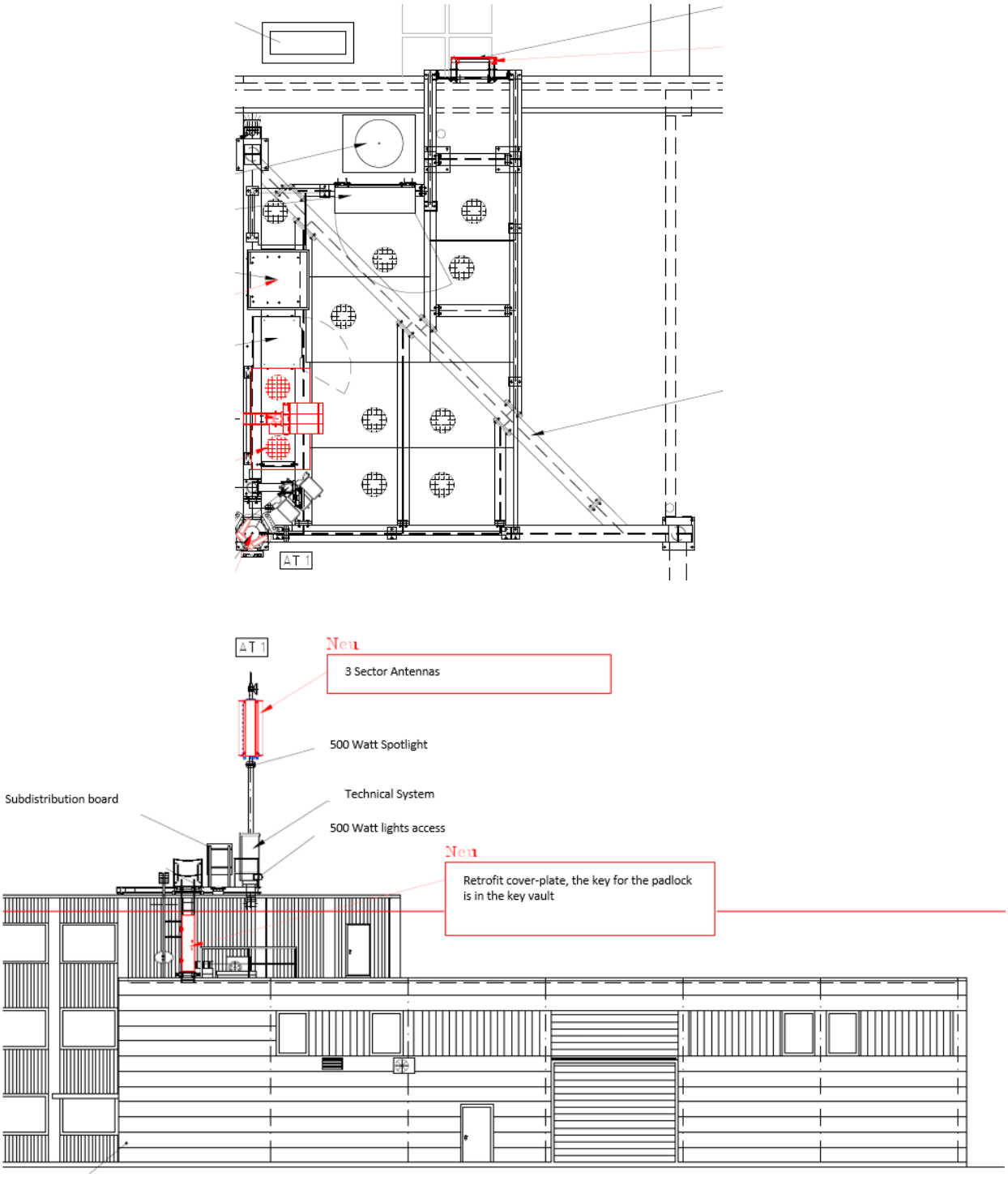


Figure 29 - Example of the detailed design of a site

This document must receive three approvals in order to proceed with the implementation phase. First by the customer, who has to confirm that the document corresponds to the solution requested, secondly by the landlord of the physical place where the site will be build, thirdly by the

government, who has to approve the running of a commercial business in an area assuring that it will not affect the local residents. The second and third confirmations are not always easy to obtain; in fact, it could happen that the solution designed is not approved by the owner of the spot where the site will be built, as well as the government could reject the request due to environmental issues. However, this happens only for new sites built from zero; when the implementation involves only an expansion there are no problems faced for the owner and government approval. If one of the approvals is missing, the solution must once again be discussed with the customer to find an alternative.

Sites can be mainly of three different types: Open installations, Indoor sites, and Outdoor sites. Open installations are the most common, simple and with highest quality of the coverage since, by positioning the radio unit close to the pole, there is a smallest use of copper cables that reduce the transmission. Indoor sites are mainly used for network expansion or swap, since the same site can have more than one base station with different hardware solutions. In this case, the Radio Base Station (RBS) and the transmission equipment will be indoor, while the antennas will still be mounted outdoors. Lastly, outdoor sites use existing property for the RBS and normally obtain the permits easily since the public installations provide a good hiding base solution.

Acquiring site information through site engineering is a process that is important also for the future projects of a company. In fact, to draft the design of the site, both information coming from the site engineering and from past guides and archives are used. The draft will then include the installation procedure, technology, tools and labor-hours required that once tested will be archived in the database for future sites.

3.3.4 Project Execution

The **Project Execution** starts when the budget has been approved and authorized. This phase implements the solution presented in the Site Design document, following the deadlines and scheduling according to the project plan (prepared during the establishment phase); however, at the same time the project status must be monitored carrying out budget and resources changes and adjustments according to the progression performance. The aim is to ensure that the project output can meet the organization and customer requirements, achieving total customer satisfaction and balancing the three main constraints of time, cost and quality. The implementation phase is one of the most important in the network rollout since it involves a joint action from different teams both on the Vendor and on the customer side. The difficulty of this stage lays in the fact that the implementation of the modules not always supports the Master Plan, lowering the efficiency of the delivery organization. In order to avoid this to happen, it becomes important to have a strong collaboration within the project team and between the project team and the customer team, and at the same time to establish standards in the procedure to reduce the mismatches with the Master Plan.

If we look at the delivery operations, we can identify three categories involved in three different macro areas of a project. First, we have the organization, which is responsible of the project team, by defining the job responsibilities of each member, and of the optimization of the communication, by providing the right tools and mechanisms. Secondly, there is the operation team, responsible of the trainings and of the war room. Third, the process and integration team, who takes care of the implementation and optimization of the requirements coming from the customer based on the Master Plan. The key of the success of the collaboration between these units is reflected by a correct

balance of the main constraints that define a project: time (schedule), cost (budget), and quality (performance and customer satisfaction).

3.3.4.1 Project Rollout

The rollout follows a priority order which is defined and agreed between the two parties during the Planning and Establishment Phase. The project is firstly divided based on Regions, then each region is divided into sub-regions and the sites of the sub-regions are organized on clusters, based on their position in the map, ***Figure 30***. The basic rollout for each region will then be based on the following criteria:

1) 2 sub-regions in parallel.
2) First pilot sites, which are the sites used as experiments to evaluate the feasibility, time, cost, external environment impact of the area and thus improve the design, scheduling and quality performance of the following sites. In fact, to ensure the quality of the network rollout, both parties define several demonstration sites to verify and decide which are the installation and acceptance standards. To analyze the results of the tests, these are done both on site and in the labs, where the expected results are defined.
3) About 30 sites/week/region based on priority. Priority which, in the case analyzed, is based on four different levels. Priority 1 is given to the sites that have to support the rollout in major cities, priority 2 to the "top 81" cities of the country, priority 3 to urban areas, priority 4 to suburban areas and rural areas.

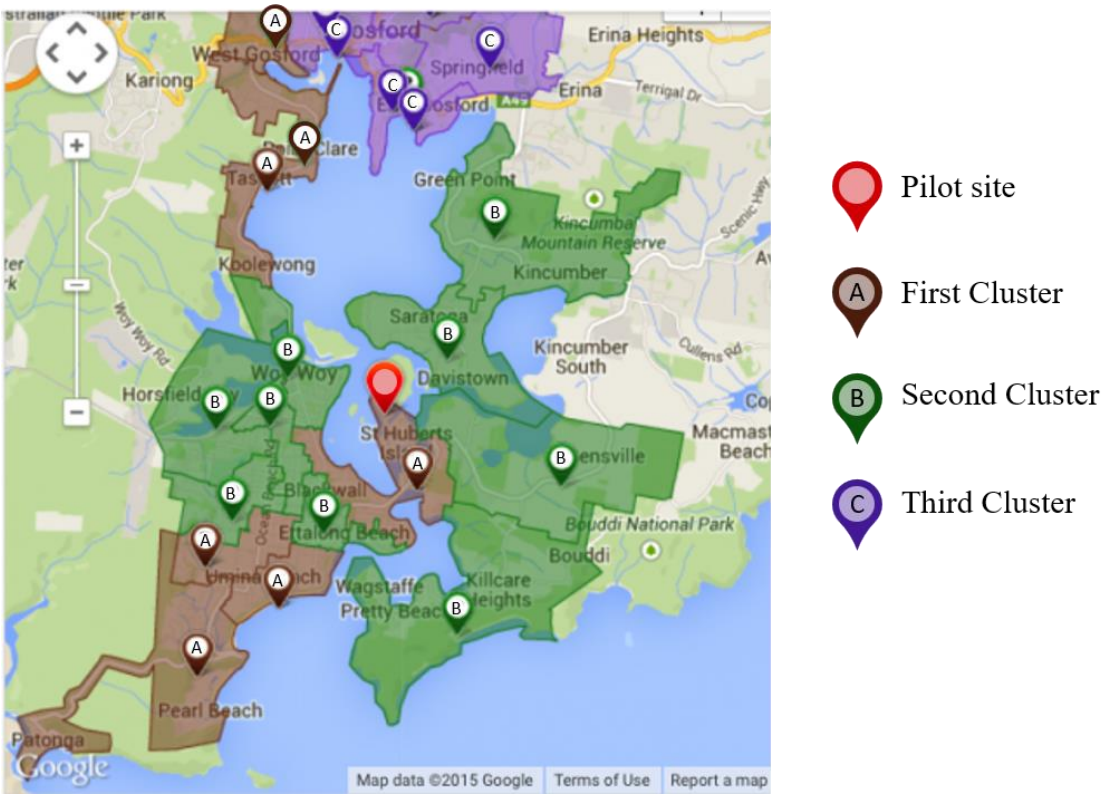


Figure 30 - Sites priority map, rollout definition

Inside each cluster, to decide which sites have a higher priority, the rollout is scheduled based on site selection tests (made during the planning phase) and the site priority matrix, which organizes the sites based on their transmission-ready complexity and acquisition-ready complexity. The sites with lower risks have a higher priority, in fact a site construction is worthless if the site is not brought "On-Air" at the right time. The total score that comes out of these tests will determine the priority of a site.

A stage that has a high impact on the performance of the overall project is the one related to the procurement and supply chain. As mentioned in Chapter 3.3.2.3, the procurement must be planned in parallel with the network planning and site preparation otherwise the materials will not be on site on time, ***Figure 31***. For this reason, the logistics team works closely with the rollout manager to ensure that the logistics program satisfies the overall project requirements. Once the site information is inserted in the system, the Supply Chain Management team organizes the material request of items that have to be transferred to the country warehouse where they will be collected only when the site is ready to be installed. If the goods are checked by the customer while they are in the warehouse, the customer has to sign a Proof of Delivery (POD) certificate, and the Vendor can start asking for the payment of the material. The material that is not needed on site must then be returned to the warehouse where it will be used for site shifts, to cover missing materials in other sites, to accelerate the rollout when it will be required by the project manager, or in case of a non-precise material forecast.

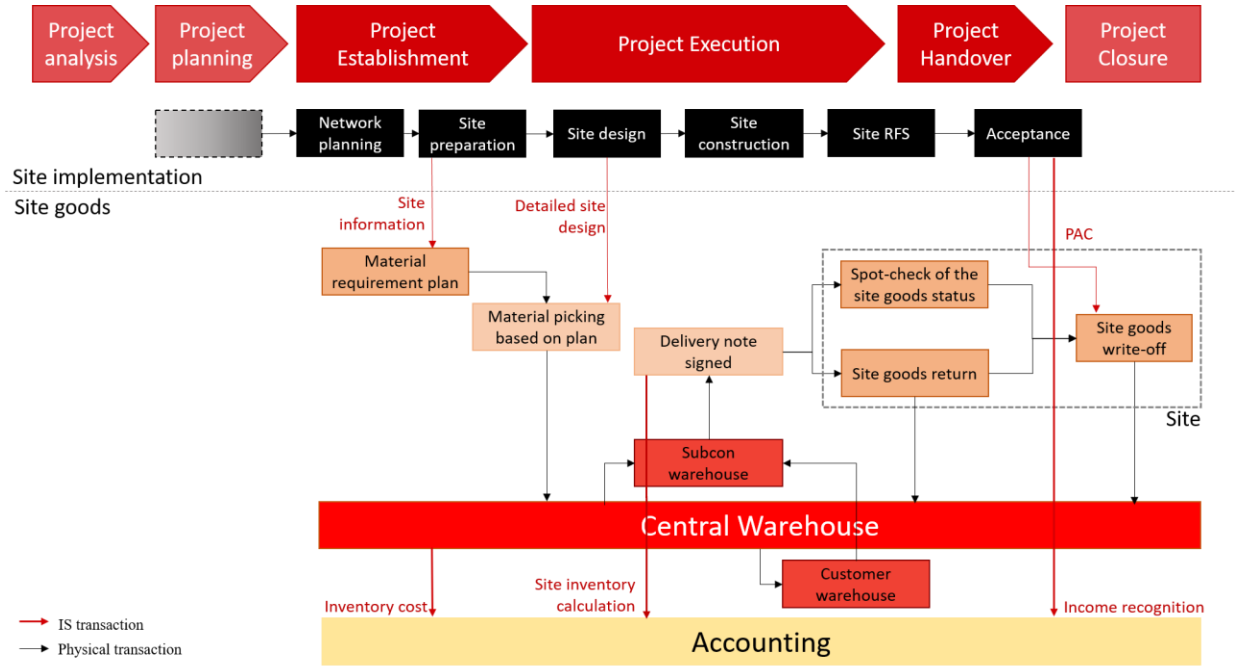


Figure 31 - Material delivery planning based on project requirements

The indicator that is mostly used to monitor the inventory is called ITO (Inventory Turnover):

$$ITO = \frac{Average\ annual\ site\ Inventory\ amount}{Annual\ carryover\ cost} \times 360$$

Where the site inventory amount indicates all the materials that have been picked up from the warehouse and signed on site but have not been paid yet (as the material that is not checked in the warehouse is paid when the site is checked and accepted). To control and have a positive ITO indicator three actions can be applied: control shipment by following the scheduling of the Master Plan; focus on inventory balance and long-term overdue inventory by optimizing the warehouse management; and settle redundant materials in time by correctly managing the low-turnover materials and the spare parts.

In order to monitor the implementation of the sites, key milestones are continuously checked. These, vary depending on the type of project that is being developed (Turnkey or SWAP), but can be organized based on six key milestones:

- Civil Works (CW): the civil works include all the activities that involve the installation of the site, from the excavation, to the concrete shield preparation, to the installation of the tower and accessories, to the installation of the generators and power connection.
- Installation and Commissioning (I&C), this milestone is reached when all the components of a site are installed, tested, operated.
- Ready for service (RFS), when the target values established in the contract requirements are reached.
- Technology in service (TIS), integration of the Node to the Network.
- Ready for Commissioning (RFC), when the site is ready to be used.
- Infrastructure acceptance, when all the quality tests are passed.

The **civil works** start with a re-check of the condition of the site one week prior to the construction day. If the installation conditions are not meeting the specifications, the installation has to be postponed until the conditions are satisfied. If the re-check is successful material is transported to site and upon goods arrival, the material is checked and inspected. Since the quality of the material normally is checked already in the warehouse, on site what is controlled is the quantity against the packing list. Shortage, damage, or cases of non-conformity are written in a report and if the Vendor is found to be responsible, the report is used as an evidence for customer's claim for replacement or supplement. It is extremely important that the equipment brought on site is confirmed and checked to prevent that issues in the payment phase occur. Moreover, since the civil works normally last less than a day, it could happen that more material than necessary is brought on site to make sure that the engineers do not to have to go back on site due to components missing. However, since the unused material has to go back to the warehouse, the equipment used is checked through a checklist. The checklist has also a second function; in fact, since it contains also the data related to the physical positioning and layout of the equipment, as the distribution of the plug-ins units in the racks, it is used as effective documentation by the site engineers and maintenance personnel in case of further checks.

Normal equipment that is delivered and built during the civil works include the RBS equipment (RRU, BBU and radio equipment), the transmission equipment, the battery backup, the tower or pole with the required cable trays, the antenna and its feeder cable and the heating and ventilation units. The amount of civil works performed vary depending on the type of site; during an expansion

only a new hardware will be necessary, sometimes together with some maintenance activities, while the whole construction will be performed in cases of sites built from zero. Moreover, the activity is performed by local subcontractors who has to complete the activities according to the contract and is responsible of the quality and safety of the outcome.

The scope of the **I&C** is to install the software corresponding to the contract and to the hardware built and testing the link, the remote control and the functionality of the whole system. Precondition to the installation of a site is that the site survey is completed and that the site is ready for installation (which means that civil works, if needed, are completed and transmission is available). The operation starts with checking all the plug-ins units, the cables and the terminations based on the documentation provided by the installation team, then the internal configuration is set up, setting the node addresses and running self-checks of the equipment, and the network is optimized by establishing the transmission connections. The commissioning can take from a few hours to several days depending on the complexity and type of equipment used. In order to make the customer familiar with the equipment, it is normally suggested that staff from the customer is present during the commissioning. Once the I&C is completed, the site is built and the power is on, however the site is not on air yet since it has to be tested first.

During the testing, technicians go on site together with the optimization center of the Customer to set the configuration of the basic parameters. The complexity behind this phase lays in the fact that, as previously mentioned, networks are mostly made by elements that come from several vendors and therefore the parameters check does not always run smoothly. In this phase, three types of tests are evaluated: test calls, speed test, and emergency calls test. The test call is carried out for each sector (considering that each site has three sectors corresponding to each of the Antennas) and for each frequency (as each standard goes in a different frequency; 900 MHz, 1800 MHz and 800 MHz for the 2G, 2100 MHz for the 3G, and 850 MHz or 1800 MHz for the 4G). The speed test evaluates the speed of download and upload for the 3G and 4G and in this case is done only once for each frequency, without having to check each sector. Lastly, the emergency calls test is carried to make sure that emergency calls are available also when there is no signal. If each of these tests reach their target values, the **RFS** milestone is successfully reached and the site is shut down. In fact, until the final parameters are not set, if the site was kept “on air” activities coming from users passing between neighbor sites would drop.

After the testing, the integration to the network can be carried out to link the new-built system to the existing network. Neighbor sites are sites within an “X” Km radius from the new implemented site that have to be integrated, based on final parameters, to make sure that calls or data coming from a final user are handed over from one site to the other, ***Figure 32***, without delays or interruptions, while passing the signal between the stations. When the integration is completed and the final tests are accepted, the site reaches the **TIS** milestone and is kept on air. From this moment on, the new site is used by the final customer, even though it is not yet paid from the customer.

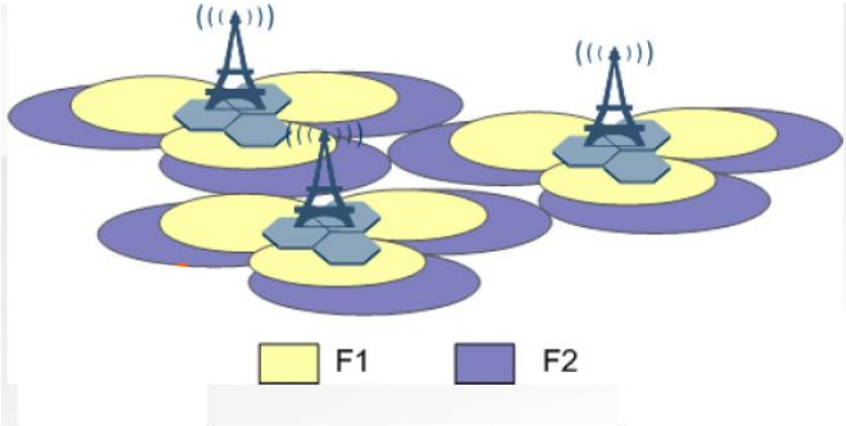


Figure 32 - Example of coverage by neighbor sites

The integration is followed by a verification that aims at ensuring that the network provides the end-to-end continuity without bottlenecks that might affect the quality of the service at a combined level when passing through neighbor sites. This activity is carried by the optimization team and consists on a car that is driven around the site area to check if the target values are reached also after the final parameters have been set. To ensure that all the tests are completed, a test document is provided, containing the details of the software loads to be tested, the testing schedule and any other information required. If the tests prove that the system is working in accordance with the agreed plan, which means that the on-site installation, the commission and the testing are completed and the equipment has been put into commercial operation, the **RFC** milestone is reached and the Customer has to sign a certificate to prove that the contract has passed the preliminary acceptance test (preliminary acceptance certificate, PAC). While if something goes wrong, acceptance tests are postponed. With the PAC document the Vendor is allowed to require for the first part of the payment (normally 80% of the total costs of the site).

Once the vendor has completed all the installation, commissioning, and integration the trial running period commences. The trial normally lasts 3 months and if the results are positive, the customer proceeds with the **infrastructure acceptance**. Acceptance refers to an activity where the supplier and customer jointly check the products and services delivered by the supplier against the contract aiming at determining whether the services and products delivered by the supplier meet the specifications. In fact, work on a product can be considered complete only when the product has been tested against acceptance criteria that have been previously established. If the acceptance is passed the final acceptance certificate (FAC) is signed, which means that the customer recognizes the products and services delivered by the supplier according to the contract. In this phase the customer must take care of several tests (agreed beforehand) to verify that the network is working as expected (throughput, signaling, software, etc.). If the phase is successfully verified, the customer proceeds with the rest of the payment, reason why this phase is delicate as a delay could lead to penalties and delays in the transfer of risks, as well as in the project closure.

Failure or delay in the acceptance phase is normally connected to quality problems or to documentation missing. In fact, to pass the final tests, several documents carefully filled in have to be submitted to the customer. These include the testing results and records, the engineering design document, the system testing logs, the report of critical quality failures, the installation checklist and the spare parts inventory list. If there are more than 5 minor mistakes, or 1 major mistake, in

the documentation the customer has the right to refuse the acceptance, which brings to enormous delays and cash losses for the Vendor.

The reason why different milestones are taken into consideration when implementing a project is that not all the products and services are produced by the same company. Therefore, if the customer decides to buy some components from other vendors, or to do part of the service by itself, the main vendor will be allowed to trigger the revenue request before the site is completed in its totality.

3.3.4.2 Project Monitoring

During the Execution, one of the most important activities is the Monitoring and controlling, a set of regular checkpoints that are used for appropriate decision making. These actions include managing project resources, securing the information flow, controlling the quality of the project, controlling the changes that occur and resolve issues that arise during the course of the project taking appropriate actions to meet the expectations of the customer. In fact, it is of extreme importance to update the project plan timely and to take measures to ensure that the project objectives are achieved following the scope, budget, time and quality forecast.

The starting point of the monitoring phase is establishing the mechanism of information collection to clearly define the information transmission channels, the format of the documentation, the frequency of the reports and the responsibility matrix, ***Table 2***. In fact, in order to improve the accuracy of the reports and the decision efficiency, a weekly report is performed by the PM, while other members will provide daily reports concerning both the time and the cost progression, that are then integrated in a weekly basis.

Table 2 - Information collection mechanisms

Participants	Type of meeting
Technical team	Daily report through call / email
Subcontractors	Daily report through call / email
Regional teams	Routine daily meeting
PM/PCM	Weekly report
Project Management Team	Monthly meeting

Summarizing, the monitoring focuses on managing the project scope to understand if contract changes are requested; budget, to generate as much revenue as possible; time to ensure that the project is delivered with the expected ratio; quality to ensure that the acceptance criteria stipulated in the contract are satisfied; and resources to ensure the availability of human and non- resources.

The scope must be monitored, since changes may arise during the project execution. In fact, as a project progresses, the people involved with it develop a better understanding of what the end result should be and what they need to do to produce the expected output. Change requests may come from different sources; the originator has to describe the change request and provide a justification for it, identifying its impact on the project scope. Once the request is received, alternative solutions and their respective impacts on the project progress and budget are identified

to find the most suitable solution that ensures a delivery within the contract obligations. If the change is internal, it cannot be avoided and therefore the budget that was set apart for the risk contingency must be used, or a budget adjustment must be made. The situation is different if the change request comes from the customer, in this case, a review of the change request is carried and a budget change is made from the PM to the Representative Office to approve the unlocking of more budget to the project. The purpose of Change Management is to ensure that the requested changes are feasible, justified and valuable, which means that they have a positive impact on the project.

The time and costs are controlled in parallel by analyzing the variances between the actual work and cost performance compared to the planned ones, determining the causes of the deviation and identifying solutions, to ensure that the project is delivered smoothly and according to the plan. In this industry, variances usually come from adverse weather conditions, weekend activities, unleveled manpower requirements, variable crew size, splitting of activities into sub-activities, and assignment of unused resources. A project manager knows that it is very unlikely that a project remains on schedule and at cost, therefore, his job will be to analyze the progression, to reduce cost overruns and time delays to minimum. During the whole duration of the Project Execution, the project team gathers weekly to evaluate the project schedule and review the achievements, making sure that all the issues are discussed and that the tasks necessary to bring the project on time are assigned to qualified team members. In general, the project team reviews the status of the progress daily, schedules the resources weekly, updates the rollout plan weekly, and review the Master Plan monthly.

Quality is constantly monitored to ensure that delivered products and services meet the defined standards of the customer. In fact, work on a product can only be considered complete when the product has been tested against acceptance criteria that have been previously established for the product. Quality assurance activities are implemented to define quality goals and develop a quality plan for all quality assurance and control activities, containing audits and inspections on site of all intermediate installation steps, as well as the final network elements, to check if the output is in compliance with the quality expectations, standards and requirements. If the activities underline a mismatch with the planned output, a quality improvement plan is carried, aiming at a better training of the resources that go on site, and at a standardization of the procedure in order to reduce the number of mistakes. To develop an effective plan, it important to constantly communicate with the stakeholders to ensure that they understand the project execution performance and the problems that were identified during the implementation.

3.3.4.3 Risk Management

The monitoring aims also at keeping the risks under control. By focusing on risk management, the project team can in fact minimize potential negative incidents and increase the possibility of project success as a risk is an event that may occur and impact a project resulting either in an opportunity or in a failure. The risk management is an ongoing iterative process based on six steps: risk identification, risk analysis, risk response, risk supervision, risk control and risk upgrading.

- Risk identification is about identifying the risks that may affect the achievement of the project objective, recording all features of each individual risk. This phase takes place already in the planning phase, since some of the major risks are mitigated in the first steps of a project, and especially because a risk contingency budget must be set and the ownership

for the risk has to be allocated. However, risk identification will keep being applied during the whole implementation, since new risks might arise and be identified.

- Risk analysis is a continuous process essential to any new or changed risk. The procedure applied aims at identifying the range of the risk influence (understanding if it affects the scope, schedule, cost, quality, or a combination of these), the alarm signs that could help identifying if the risk is taking place, the probability of occurrence, the cost estimation (which can either be a specific value or a percentage of the total) and the risks connected to it.
- Risk response is made of measures that can eliminate or mitigate the risk influence, these are a series of actions that can ensure the project success and directly reduce the project risk. All risks should be assigned to a specific owner, who will be responsible for the response, so that the response plan can be implemented smoothly. To reduce a risk, two strategies can be followed: a precaution strategy, which transfers, reduces or avoids the risk in advance; or an emergency strategy, applied when the risk occurs.
- Risk supervision refers to the supervision over high-risk events identified in the risk management plan, and identification of new risks based on project implementation and project environment change providing updates to the risk list. Once a new risk is identified or the risk environment is changed, new evaluation or certification should be made to appoint it with a probability and influence the project.
- Risk control aims at monitoring the risks, updating the plans through a monthly report. Depending on the type of risk, different measures can be used: emergency plan, tack measure, project change request, and backup solution.
- Risk upgrading is about changing the status of external risks and requesting senior assistance in case of high-risk events. When the project manager escalates essential issues to the Steering Committee, the customer may also be requested to participate, in order to find the best solution to successfully deliver the project. External risks refer to risks beyond the control of the project team, such as marketing transfer, government behaviors, etc.

In the business analyzed, risks can be mainly of three types: commercial, solution, and delivery. Commercial risks are connected to the financial environment, to the taxation and exchange risks (both due to fluctuations), to penalty risks that arise when the Vendor is not able to fulfill its commitments, and to customer credit risk, which is the risk of losses due to payment delay or inability to pay on customer's side. Solution risks arise when the project team is unable to correctly fulfill the customer's requirements, when there are technical problems with the developed solution, or when the project is not on-time and it comes into the market as an immature service. Finally, there are the delivery risks, which are risks that happen with a higher frequency:

- Resource availability risks, which bring to unexpected costs due to resource readiness delay;
- Product, technology, and quality risks;
- Project plan risks, which have to do with mistakes made in the project planning;
- Contract changes risks, which, as mentioned several times, increase the costs to respond to unexpected contract modifications;
- Commitment and communication risk, which means wrongly handing over of commitments and information;
- Subcontracting and outsourcing risks, as the subcontractor's poor competence or management and its inability to timely fulfill the obligations could increase the costs;

- Environmental risks due to unsafe working conditions or health issues;
- Site readiness risks, which increase the costs when the site is not ready for the delivery process on time;
- Acceptance risks
- Supply and logistics risks;
- Invoicing risks, due to lack of supporting documents or misalignment between acceptance and invoicing milestone;
- Maintenance transition risks that arise when there is unavailability of maintenance engineers when they are necessary.

3.3.5 Project Handover

The handover is the last phase that is part of the cycle, as the Project Closure will then represent the closure of the whole project. With the handover, the PM has to ensure that the project achievements are officially accepted by the customer and that the PAC and FAC documents are correctly signed. Only when the documents are sent to the CM, the revenue trigger can be submitted to receive the payment from the customer; bearing in mind that the PAC and FAC do not need to be submitted simultaneously, which means that the part of the execution passes to the handover phase, while part of it still has to finish the implementation.

It is important to bear in mind that the job of the team, including the one of the project manager, does not end with the completion of the rollout as once the site is fully commissioned, operative and in commercial use, two phases take place: the care management phase, and Operations and Maintenance (O&M).

- The Cara Managements gives the Vendor responsibilities regarding agreed services that must be solved properly and timely. In these cases, the Vendor will be responsible for arranging, at its own costs and risks, the solution and reparation of not-functioning units, both on the hardware and on the software side. Depending on the failure report, different priorities are assigned to the fault and a schedule to repair is decided. Included in the care management service is also the software maintenance as the software is subject to continuous releases that add features or improvements.
- The O&M services are created to assist, support and consult the operator. The first step included in this service aims at training the customer's resources to correctly run the network. While the second part includes consulting the operator on expansions and upgrades. Expansions are recommended when the capacity of the existing hardware does not fulfill the user's requirements. To solve the problem, if the additional request is not very high, extra plug-ins can be added, otherwise there could be the necessity of adding news racks. Regarding the software, this can be upgraded with new packages that bring new functionalities, improved performance, higher success rate, improved network stability, etc. The business of the Software upgrade is becoming quite important and profitable by separating the feature-based software modules from the basic-operation software modules. The third part regards network maintenance and the regular checks that are made in the network either by going on site or by operating remotely. In the business there are several network monitoring systems that extract data from the database and operate a series of statistics to help evaluating the faulty

situations. Remote health checks are an excellent way of ensuring that the network is stable keeping the personnel and maintenance costs low.

3.3.6 Project Closure

The close-out is a major activity in the project lifecycle; failure to release project resources and summarize the major events about the project could lead to expenses coming from claims and disputes. This phase is mainly made of three points: commissioning, termination, and feedback learning.

Commissioning focuses on assuring that all the work is completed, that all the claims are solved, and all the documentation is prepared. Once all the sites have been completed and the PAC and FAC documents have been revised by the CM, one of the main activities related to the commissioning is the Project Final Accounting, a report that reviews the loss/profit analysis and the inventories and assets that are left from the project. The solution is then reviewed by the PM and TD, who have to go through all the documentation to ensure that it is complete and that the risks that were identified during the project cannot impact its closure as all the ownership has been transferred to the customer. During this phase, also the customer satisfaction is evaluated by interviewing the customer and reviewing his responses regarding the satisfaction over the phases of the project. The customer satisfaction survey is important to improve the project handout.

The termination involves the operational activities that take place to dismantle the sites' facilities and to release the resources to new projects, and the definition of the maintenance conditions and obligations. A project can be then closed the following conditions is met:

- All delivery completed and 100% revenue recognized, or if not all deliveries completed at least 80% of the revenue recognized,
- 100% of labor cost paid,
- Goods returned from sites that are cleared,
- All delivery responsibilities fulfilled.

Lastly, the feedback involves the summarization of the experience and the knowledge sharing creating a report that is added to a sharing platform where knowledge is exchanged to improve the delivery capabilities. The report includes the documentation prepared during the project planning (WBS, CBS) and the information generated during the implementation (activity duration, productivity rate) to improve the future project's methodology and process estimation.

3.4. Organization

To handle and manage projects of such complexity it is not enough to have a well-defined process with the activities clear to all the project members, but it is of extreme importance to have an organizational structure that fits the process and the company. In fact, only with a correct organizational structure the communication can be efficient, with the authorities clarified and the responsible person designated, and the work can be more productive, as the organization can provide a roadmap for rules, time, means and changes.

The organization in this industry is project-oriented, and the responsibilities are defined within the project management teams taking into consideration that the team has to interact with different

interfaces both internally and externally (customer and partners). A good organization will boost the project performance, while a bad one will work as a blocker. It was mentioned how to survive in the business the Vendors have to provide the most advanced technologies in the market and thus continuously quest innovation; for this reason, the organizational structure of the companies is of an ambidextrous type. Ambidextrous organizations focus at the same time on exploiting the existing market and exploring new solutions to ensure that the business is aligned with today's demand, but at the same time is ready for changes. In the Telecom industry ambidexterity is achieved through a dual organizational structure, where one business unit focuses on serving the customer, while the other on looking for blue oceans. The first business unit, which includes the teams that execute the projects, manages the exploitation, while the second one, defined with the Research and Development (R&D) unit, manages the exploration (***Figure 33***).

	Exploitative Business	**Explorative Business**
Strategic intent	Cost, Profit	Innovation, Growth
Critical tasks	Efficiency, incremental innovation	Adaptability, breakthrough innovation
Competencies	Operational	Entrepreneurial
Structure	Formal, mechanistic	Adaptive
Rewards	Margins, Productivity	Growth
Culture	Efficiency, low risk, quality	Risk taking, flexibility, experimentization
Leadership role	Authoritative, top down	Visionary
	⬇ Project team	⬇ R&D

Figure 33 - Exploitation and Exploration through project team and R&D

Exploitation is in fact a characteristic of the project teams as their main goal is to satisfy the customer by bringing to the market the solutions experimented in the exploration phase and making profits out of it. The teams will thus focus on how to increase the efficiency and the productivity. Looking at this first business unit, the trigger for a good organizational structure is thus to understand the type of project being carried. As mentioned in Chapter 1, these are of three types: adding capabilities into an existing network, establishing a specialized business network for the enterprise business, and establishing establish a temporary network. While in the description of the processes only the first case was carried out, as being the more general and complete, in the organizational point of view the differences are bigger and have a greater impact and will thus be presented as separated cases.

On the other hand, exploration aims at establishing units that focus their attention and energy on improving the products through either incremental innovation, which is achieving small improvements in the existing products, or through discontinuous or architectural innovations, which bring to fundamental changes and radical advances. The R&D team, which fulfills the

exploration tasks, has a very risky business as not always the output is successful or useful for the business. For this reason, as it will be described in Chapter 3.4.2, it is important that the exploration department is coordinated with the exploitation one.

If we look at the organizational structure of the Vendors, ***Figure 34***, at the higher level the exploration and exploitation teams are separated, while, going into detail, on the exploitation side there is a department for the network expansion, commonly known as the Delivery & Service department, and for the business network expansion, the Enterprise business. Some functions are thus specific of one department, while others are shared between the whole company to have economies of scale and knowledge sharing. The case of the temporary networks, on the other hand, represents a specific case of the Delivery and Service and is therefore considered as part of it.

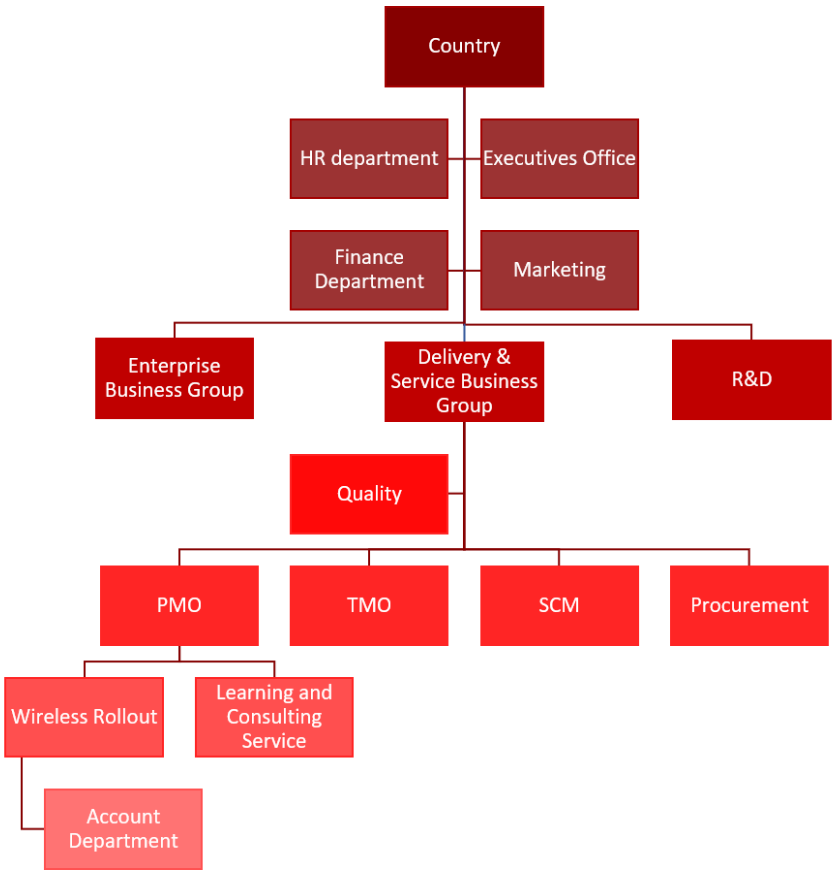


Figure 34 - Organizational Structure of a Telecom

3.4.1 Delivery & Service business unit

Starting from the Delivery&Service Department, as mentioned in Chapter 3, it controls the business scenarios that go from the Network rollout and integration, to customer support, to consulting and assessment. Looking at the network rollout, the service provided includes then providing integrated solutions that contain end-to-end integration or turnkey services either for wireless or fixed network and develop. Of course, based on the specific type of project there will

be minor differences in the organizational structure due to the fact that each service has a slightly different process, but the overall matrix is the same. On the other hand, the customer support and the consulting have a quite different organizational structure, as the service offered has major differences.

In this case, the Vendors have several projects that are carried out in parallel for several service providers. However, these projects tend to be similar and for this reason the structure definition and the allocation of the tasks do not suffer of many changes. This fact implies that the biggest pain point for these companies will be the coordination between the projects, especially regarding the resources that are shared, the controlling and the management of the portfolio/program to align the projects to the strategic goals. The organization will thus include on one hand the operational employees that execute the project, on the other the management who makes the decisions, schedules, monitors and controls. In order to have a successful project, these two parts have to coexist, working in an effective way with qualitative interactions.

3.4.1.1 Managerial level

At a managerial level, the responsibilities are related to a correct leading of the organization to ensure that the projects are carried out as expected and following the standards of the company and the objectives of all the stakeholders. This means putting up the right team with the right number of resources to create the conditions to support and foster the project. If we look first at a higher level, the company has a program and a project organizational level. The program organization is a two-layer structure (Governance and Management) with three key teams: the Steering Committee, the program management office and the technical management office.

The Steering Committee is an advisory committee made up by high level stakeholders that provides guidance on key issues. Its responsibility includes assuring key resources at the corporate level, communicating with executive customers, deciding upon key issues, steering project operations, and enlisting the help of customer executives for boosting coordination among vendors. The Steering Committee is thus responsible of tracking the project and securing its success by assuring that the commitments are fulfilled and that the team is correctly supported (especially on a budget point of view) to achieve the goals. The Steering Committee has a great impact in the Telecommunications industry as there are many units, including the customer and the partners, that impact the success of the project.

The management of the projects, however, is in the hands of the **PMO** (program management office) and TMO (technical management office). The PMO is responsible for managing the program operations and profitability, ensuring that the projects that compose the programs are correctly integrated and that the resources are well balanced. The advantages of having a program management office is related to its ability of creating clear structures and terminologies that are shared between the projects pushing towards the creation of an organizational project culture. Moreover, the PMO reduces the hierarchical organization and the span of control of the higher levels, increasing the efficiency in the management by providing resource plans and implementation tools to support the contract delivery on time. At the same time, being responsible of the resources and the communication within the teams, the PMO develops communication modules to strengthen the information exchange between the functional and project team.

The PMO director is the owner of the integrated collaboration between the projects, which means that he defines the master plan of the overall program to determine the delivery priorities and allocates and coordinates the resources to ensure that the delivery of the projects under the program are successful. At the same time, the PMO director is the interface with the Steering Committee, which means that he has to manage their expectations by developing a plan of communication ensuring that the information are correctly spread across the organization and with the customer.

The **TMO** on the other hand is responsible of the delivery solution, including the network planning and design, managing the requirements that differentiate the projects and ensuring that the different vendors and products are integrated correctly in the solution. If the Vendor has a TMO that works efficiently, in the short term, the project runs seamlessly and, in the long term, the company is able to manage their technologies to create a competitive advantage. In fact, the technical department is responsible of understanding the value of each technology to use it correctly and timely in a project. The strong relationship between the TMO and the product portfolio of the company implies an interaction with the research team to be always on point on the technology strategy and forecasting. For this reason, the TMO also includes figures shared with the R&D department. The importance of this department lays in the type of business analyzed. In fact, while in order companies the presence of the PMO is enough to coordinate and control the activities, in the Telecommunications industry the impact that the technical solution has on the result is high.

The TMO is made mainly by five figures:

- Technical Director (TD): the TD is a key role in the delivery solution as he is the technically responsible for the project and the production of an output that is feasible to deliver, feasible to acceptance, of high quality, and cost effective. He has to ensure that the deliverable follows the customer requirements and that risks and opportunities are taken into consideration when deciding which solution to implement in a project. The TD is responsible for the construction, operations and technical management of the technical team, that is under his span of control and not of the PMO. The TD has to ensure that a network planning and design is provided, that the sites are correctly implemented and that the network is secure and optimized at the end of the implementation, ensuring that the skills and competencies of the technical team can effectively meet the delivery requirements. Once the project is over, the TD has to provide a roadmap, which becomes a knowledge base that is then shared between the project.
- Network plan & design team: responsible team of the research that is done once the company receives the requirements from the customer. In fact, through the requirements and the deliverable objective, the design team is able to prepare the HLD and LLD solutions that will then be used in the bidding phase and as documentation for the implementation team. The requirements are analyzed using the roadmaps kept as documentation from finished projects in order to have in mind what the key problems were and how the output can be improved. However, also when the design is finished, the tasks of the network team are not finished, as their responsibility also includes assessing that the output solution is correct both in a design point of view and on a performance point of view.
- Network assessment and optimization team: responsible of the service quality and customer satisfaction by continuously monitoring the performance and quality. In fact, only through a deep understanding and monitoring of the quality a better output can be created.

- Troubleshooting team: responsible of the problems that arise during the delivery through analysis of the network faults, by then providing recommendations on how to improve the network.
- Service launch team: assists the customer in establishing the service launch capability by developing a process that ensures a smooth and correct launch.

3.4.1.2 Execution team

The execution team is organized in three different modules: the function, the region, and the project management. When setting up the execution team the Project Director (PD) looks at the skills and know-how that is necessary to succeed in the project and then chooses the resources that make the coordination work appropriately. A combination of technical skills specific for the industry together with organizational and interpersonal skills, represented by the project management office, are what creates the right combo.

In this type of projects the structure of the execution team is of a Matrix type with the functions interacting with the project departments and sharing resources within them, ***Figure 35***. In this organizational structure, as presented in Chapter 2.3.1, the responsibility is shared between functional managers, also known as line managers, and project managers; the authority of the project manager flows sideways, controlling resources from different functions, while the authority of the line manager flows vertically, which means that the members of the project respond to two different figures. Since the PM is responsible for the project planning and scheduling, deciding on the tasks that have to be performed and when they have to be performed, while the functional managers decide on the resources that are assigned to the project and the structure of the process/technologies/know-how used, the importance that is given to each one of them will impact the way in which the project will be handled. In particular, in the Telecom industry, at the moment most of the companies use a so called “lightweight” matrix, which means that the line manager has a higher importance than the project manager, who has mainly a coordination role, and that the resources respond thus firstly to him. This choice has pros and cons, reason why, looking at the direction in which the business is going, the model proposed will tend in the direction of a strong matrix function.

Pros:

- The project focuses on the quality of the output, which is a very important factor to succeed in the industry;

Cons:

- The line manager decides how to allocate his resources, which means that PM has to adjust the project schedule to their decisions;
- The management impose changes without always including the PM in the decision, which means that the plan will have to be updated, idealistically without impacting time and cost, which is unrealistic;

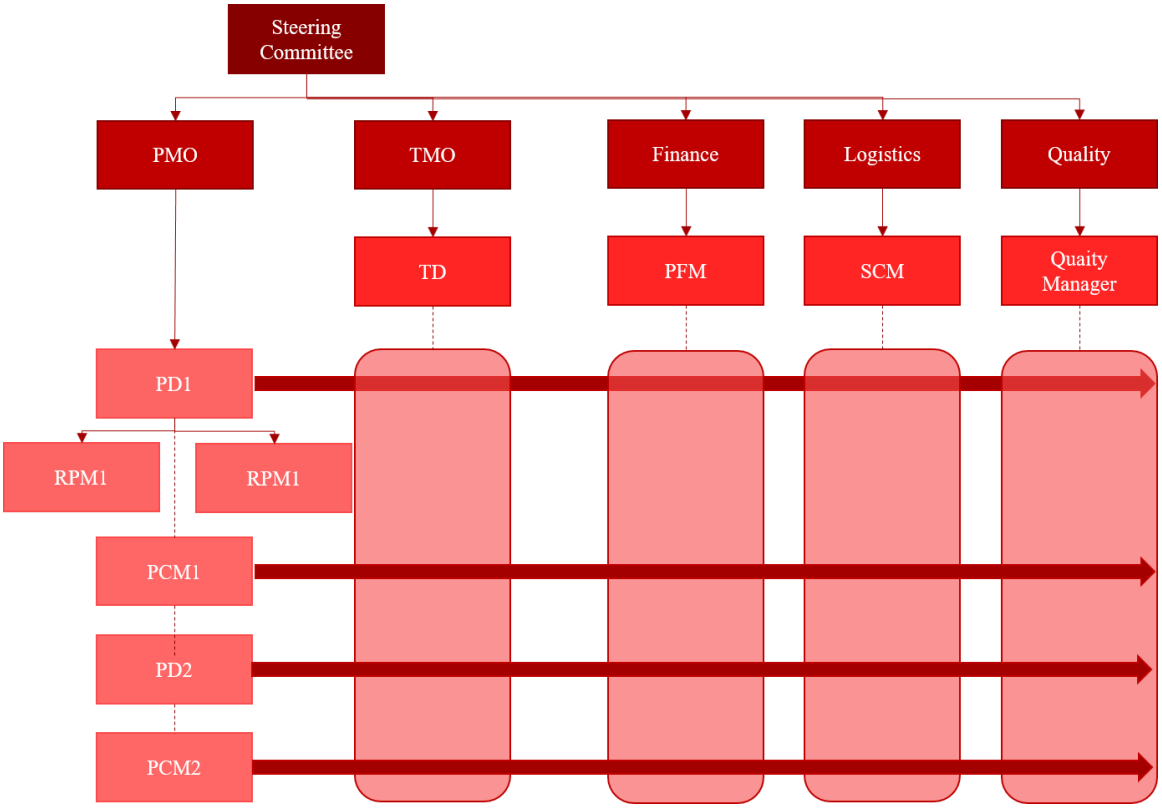


Figure 35 - Organizational matrix structure of a Vendor

3.4.1.2.1 Project Management

Going into detail in the matrix, the project management represents the major entity that manages the execution, being responsible of the implementation, customer support, services, and operational process development. In companies that produce value through projects, the project management team has a high impact on ensuring that the results are achieved, as coordination between the management, the functions and the regions is necessary to fulfill the constraints of quality, time and scope. Objectives of the project management include managing the scope of the work, the scheduling and costs, as well as fostering a good project context and environment. Each project has eight core members, called the C8, that are part of the project management office and represent the critical roles of the project. These are: the project director (PD), the project finance controller (PFC), the contract manager (CM), the technical director (TD), the project control manager (PCM), the SCM manager, the quality manager (QM) and the Procurement Project Manager (PPM).

As the primary owner of the project, the **PD**, who is also known as the Delivery Project Manager (DPM), is responsible of the achievement of the goals of the project both in terms of operating results and customer satisfaction, ensuring that the project is enforced according to the requirements presented in the contract on a cost, time and quality basis. As the PD is the "mandated representative" responsible for all the contractual and management aspects of the project, he has to develop the delivery strategy and the project integration solution, managing the implementation and monitoring the progress of the project, and organizing regular meetings with the team members to decide on major issues and key points. In these projects it is in fact extremely important to

involve all the team members in major issues as if an agreed solution is not found, major delays could occur. The tasks of the PD include: building the project environment by choosing the team members, defining the delivery strategy of the project, leading the resources to provide an harmonious environment, coordinating the project operations at a higher level transmitting the information to the PMO and Steering Committee when risks beyond the scope of project management are found.

The Product Director is responsible of the whole project, from the quality to the time and scope. Its obligation is in fact to provide the output meeting the solution design requirements, keeping the lead-time of the deliveries and ensuring that the works are completed with the expected quality level. However, his impact over the project vary depending on the process phase, with his importance laying especially in the monitoring and controlling phase and as a coordination role (***Figure 36***).

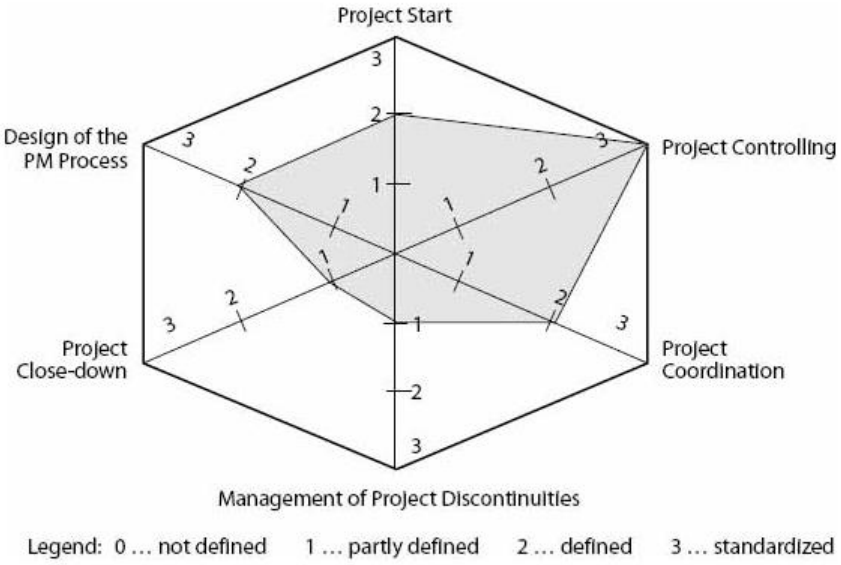


Figure 36 - Impact of the Project Manager in each Project Phase

In fact, if we look at the process progress presented in Chapter 3.3, the PD normally does not participate to the first phases of the bidding and designing process since there are more expert figures. The bidding is thus managed by the sales team, which however often requires opinions and advices from the PD that will then manage the execution in order not to incur in problems later in the project. Getting the PD involved in the pre-sales ensures in fact that a coordination between the different domains is settled to guarantee that the feasibility analysis is the more accurate possible.

The designing and planning is mainly managed by the technical departments and functions responsible of the activity. For example, the logistics will be prepared by the SCM, the technical solution by the TMO, etc. This is the main reason why functions exist and why the projects have the coexistence of the project management team and of the functions. In the planning phase, the PD will thus have a more marginal role for what concerns the technical design and functional planning, focusing his activity on ensuring that the scope of the project and its costs and time estimations are accurate and feasible.

The greater impact given by the project manager are thus as controller and coordination roles. Under its span of control, the project manager has to manage and coordinate the functional teams, ensuring that the teams are working correctly and in a goal-oriented way and this will only be possible through a well-motivated and coordinated team, where all the members actively perform their duties and where conflicts are resolved before they become an issue for the project.

To monitor the project, Project Directors must ensure that the key aspects of the project are translated into a set of indicators that can then be related to the plan. Only with this background of information they can take the necessary management actions to ensure that the project is completed successfully. The relevant information falls into several categories: time (especially the key dates represented by the milestones), resources (such as manpower used, or estimation of effort remaining), work completed or in progress, costs (of resources, materials, services, etc.), deliverables and their progress towards completion, issues, risks and changes.

In all these phases the Project Director will have a high impact, requiring a strong ability to manage and control the execution of several projects at the same time, analyzing the requirements and constraints that continuously change the project trying to keep at the same time the costs and time requirements. The project close-down has again a lower impact and importance of the PD, who is responsible of ensuring that the results are handed over both internally and externally, but is not responsible of the allocation of the resources to new project and of completing the customer satisfaction evaluation and lessons learned. These actions are assigned in fact to the PMO.

The **PCM** is responsible for the implementation of the Master Plan (presented in Chapter 3.5.1), which is formulated based on the contract and integration plan developed by the technical director. Even though the Master Plan is developed in the early stages of a project, it has to be constantly updated. Reason why the PCM is responsible of the monitoring of the implementation, focusing especially on the plan timeliness and accuracy and ensuring that the Master Plan is integrated to the third-party plans to ensure the feasibility of the implementation. The PCM is responsible of developing planning and management rules, supporting the Project Director through updated reports that evaluate the progress of the projects, identifying the issues in time in order to ensure that corrective measures are taken. Lastly, the PCM works as an interface between the project and the regions; in fact, as it will be presented in the following pages, the Regions are the entities responsible of the physical execution, and since they are spread in the country, the PCM is the figure that collects the information, monitoring the pace and updating the Master Plan forecast and proposing corrective actions in case the project is falling behind schedule.

The **Contract Manager** (CM) is the point of contact between the Customer and the company regarding contractual topics to ensure that the responses are timely. The CM organizes the contract handshaking and interpretation, checks that the documentation is complete and that the contract is feasible. To achieve this goal, the CM has to be familiar with the operations of the project, but also with the culture of the organization and the needs of the department to ensure that all parties are satisfied. Therefore, it is a position that is required and very active in the first phases of the project, when the contract has to still be stipulated and he has to negotiate with the customer attorneys, but also during the execution phase. In fact, whenever a change has to happen, the project director uses his guidance and documentation to control how the change would affect the contract agreement and how to handle it with the customer. Moreover, throughout the duration of the project, the CM works with the Finance department to ensure adherence to finance and risk requirements regarding the revenue recognition, the pricing and the discount policies that can be introduced during the execution of the project.

3.4.1.2.2 Functions

The other members of the core 8 work as an interface between the Project Management and the Functions. The functions are defined by all the processes necessary for the success of the project; from the quality, to the supply chain, to the procurement, to the finance. These have a line manager, who is a core 8 member, and resources that are shared between different projects who are coordinated by him. The presence of both a line manager and project manager, working both as authorities for the functional resources, can create several problems as mentioned in the beginning of the chapter.

Moreover, managing the functions is a complicated task because there are exchanges of resources across several teams, in terms of working hours, and resources that are more and more dispersed in a geographical point of view, increasing the necessity of virtual communication and coordination and thus of a proper I system. The fact that the resources are shared between several teams brings to coordination problems under two points of view: the time that each resource spends on a project will have to be decided and the hierarchical importance of the figures will have to be appointed. Regarding the time, resources are allocated based on the importance of a project and on its performance by looking at several indexes that help understanding if a project is on-time or not and how many resources are requested to bring the project on-time. Looking at the telecommunications industry, the lateness of a project will not always be connected to the number of human resources, who are mainly important in the roll-out and construction phase, but also to the physical resources (hardware).

The **quality team** is responsible of developing a project quality plan, defining quality goals and develop the plan for the control activities that have to be carried, which contain the audits and inspections for all the intermediate installation steps as well as the final acceptance. Moreover, the team has to ensure that a high-quality solution that fulfills the health and safety environmental requirements is produced. The responsible figure for the quality team is the QM, who has to develop a quality assurance plan that defines the quality monitoring during the implementation, necessary to ensure that the quality requirements are satisfied. The quality standards that have to be reached are defined both by the customer and by the industrial standards, without taking for granted the regulations and standards imposed by the law. To assure that the quality expectations are met, the team has thus to work on three different levels: looking at the local environment for installation quality check report, performing on-site inspections, at a regional level to fulfill the regulations and at a worldwide level when there are higher quality issues with the technical side of the project.

The **supply chain** team is responsible of the end-to-end supply and inventory management of the project, going from the purchase orders, to the delivery of the equipment to the site, taking care of the organization of the warehouse and the delivery of the materials to the site. The Supply chain manager has to ensure that the supplies are accurate, timely and consistent with the actual data provided by the project, to support a smooth progression of the project. In fact, if the logistic process works smoothly and the material is delivered in the right quantity, to the right place, at the right time, the chances that there are issues during the rollout are a lot lower. The implementation of the supply solution is not implemented by the project team, but is defined by the SCM, who has to integrate the installation and delivery plan to ensure an effective functioning of the project cycle,

constantly tracking the deliveries to ensure that appropriate actions are taken if the material cannot be delivered on time.

The **Procurement** team, led by the PPM, is responsible of the procurement operations, organizing the selection of the subcontractors based on the quality and quantity requirements and ensuring that the project is supported by a timely procurement process. The PPM has in fact to ensure that the suppliers selected can meet the demand, which in this kind of project is variable, by providing flexible resources allocation and the quality expectations, by providing training on procurement policies, rules, and strategies. In case of supplier issues, such as low quality or inadequate productivity, the PPM has to timely escalate to the management.

The **financial** team, headed by the PFC, is accountable for project risk exposure to financial losses, as it has to set up and manage the accounting operations, controlling the budget and the cash management, and providing to the project manager suggestions to optimize the project costs. The job of the finance team works in two directions: first transferring the required funds to the regions to fulfill the payment of the partners, second to track the payments from the Customer. As easy as it may sound, the payments in the construction industry do not always go as smooth as expected; the Customers try to postpone the payment point to the point where they start making revenue starting quality disputes that may take years to be resolved. It is thus responsibility of the financial team to analyze all the appropriate payment options providing information both internally and externally on how the transactions will be carried out. At the same time, the PFC has to manage the project performance in terms of budget, providing assessment results that identify operational activities that affect the quality of the financial results or risks concerning the exposure to financial losses.

3.4.1.2.3 Regions

Lastly, the regions are the entities that are responsible of the execution phase by performing the tasks described in the plan to ensure that the deliverable is implemented on time and following the requirements of the customer. The implementation team focuses on everything that has to do with the construction, from the site survey, to the equipment installation, to the software testing and system integration, to the technical support during the commissioning and final integration; and due to the tight relationship that the regions have with the rollout, each region will have its own Project Manager, called the **RPM** (regional project manager). The RPM is responsible for the delivery, defining all the tasks related to the implementation of the network elements, defining thus the installation planning, based on the milestones defined in the Master Plan and in the progress of sites already completed. He has to transmit the progress to the PD to ensure that the Master plan is up to date. At the same time he is the main interface with the customer for regional requirements and has to promptly escalate issues and risks that are beyond his capability to ensure that corrective actions are taken on time.

The relationship that the engineering implementation team has with the TMO is that the TD provides the technical support and work across several projects, while the implementation team implements the projects. Moreover, while the TMO is made only of internal employees, the Regional team includes also the subcontractors that support the implementation. Each region is responsible of a geographical area of implementation overseeing the subcontractors that participate in the implementation progress taking measures over major issues and risks that have to be timely solved.

3.4.2 R&D

As mentioned in the introduction of Chapter 3.4, the companies in the industry are of an ambidextrous type. While the organizational structure of the exploitation is of a matrix type, overall there are some activities, which are outside the project control, and that focus on the exploration that work with a functional perspective to maximize the know-how, by keeping experts and specialists together, and to focus on the activity that is of highest importance, without looking at the singular projects and their development. These activities are related with units that do not need to belong to a project but whose knowledge is shared between the whole company. A functional organization is in fact typical in departments where a strong focus is given to the technical know-how and through the functional organization it is possible to maximize the knowledge and experience sharing. A company that invests on innovative projects, and as mentioned in Chapter 3 the Vendors have a continuous quest for blue oceans that will increase their position in the market, tends in fact to have a specific organization for the research department. Here, leadership belongs to technical experts and it is not necessary to integrate the activity to other functional units to be successful, therefore the organizational structure will not have project managers and the knowledge and research efforts will be shared among all the projects of the company.

The organizational structure of the R&D department is highly influenced by the strategy of the company, and therefore influences at the same time the direction in which the company goes. The research centers have thus to understand the business strategies and requirements, both internal and of the customer, to support the development of a solution that is addressable to the market. In fact, starting from the understanding of the corporate strategy, the R&D department has to provide an analysis of solutions that push to an increase in the success of the company. The demand coming from the market is massive and keeps growing as networks are always needed, and especially with the boom of IoT pipes that have a large capacity are more and more required, which means that blue oceans are always available. However, in order to innovate in the right direction, the R&D department has to be driven by the right set of values, which in this case is the customer centricity. Focusing on the customer needs, both the obvious and the ones waiting to be discovered, engaging with customers face-to-face and gaining understanding of their practical requirements are the right way to boost innovation.

Especially in the telecom business, where the main Vendors are spread worldwide, a lot of attention is thus given to the dispersion of the research centers trying, on one hand, to be close to the headquarter where the strategy of the organization in located, on the other close to the place where the scientific and technical knowledges are the highest, where the competitors can be under continuous surveillance, and where the interaction with the customers is stronger.

To strengthen and increase the efficiency and effectiveness of the R&D, Vendors normally have more than one research center, each focusing on one or several technologies and each in a strategic location. Decentralizing the research, destabilizing a central and vertically controlled R&D, allows to increase the vitality of the team, at the same time, by ensuring that the approach to product development is well-defined, the success of the team is boosted.

3.4.2.1 Decentralizing R&D, while centralizing the technologies

Decentralizing the R&D department allows to build the centers of expertise in places where talented people and advanced technologies are. Since the business strongly relays on talent, there would not be a point on bringing the talent to the facilities, when a facility can be built where the talent is. Moreover, the environment is crucial in nurturing innovation as it allows to constantly interact with people highly involved in the business and through the knowledge sharing new innovative projects can be boosted.

At the same time, centralizing the R&D of a type of product encourages the development of long-term projects, sometimes risky, that increase the likelihood of creating fundamental technological advances. In this way, the business is continuously pushed in the direction of finding new blue oceans that increase the market share and the profit, as innovation and transformation are two of the most competitive edges for growth in the business. However, the centralization of the R&D centers has also a disadvantage, as by disconnecting the departments between each other and by not working closely with the project teams, there is a risk of having projects that do not go with the requirements of the market. To solve this problem, the research centers have to be interconnected with the projects and business units through senior managers and through a "lessons learned" process, which works as a communication channel by which the pain points of the project, and thus of the outcome, can be transmitted to the research center who takes then charge of the improvement of the delivery solution.

A good organizational structure, is fundamental for the success of the department to compensate the uncertainties coming from the results of the researches. The team is thus organized in a functional way, with the technical leaders that receive as much recognition and prestige as the managers that lead the team to continuously attract the best people. Since the research centers are structurally independent and have each its own process, the role of the managers is to ensure that the research unit is integrated into the existing business. Managers work as links between the research centers and across the project teams to coordinate the evolution of the research and to ensure that the innovation is going in a customer-centric direction through a constant interaction with the TMO. At the same time, the technical leaders are fundamental to push the thinking and development into unknown areas. For this reason, to ensure that the team is correctly challenged, the company normally also sets up a second technical team that focuses on trying to deflate the main team, bringing up the unpleasant truths and pushing the team to constantly provide a better solution.

3.4.2.2 Definition of a shared process

Decentralizing the research teams allows to increase the chances of finding a new blue ocean; however, to increase at the same time the chances of success, it is important to have the research centers related to the same technology centralized and to define a process that correctly manages the product development of the team.

The process of each research project is divided into stages and checkpoints that work as decision-points on if to keep the research going, or how to improve the process to increase the chances of a success. The reason behind the definition of the stages is that it increases the possibility of knowledge sharing within the company, ensuring that successful practices can be copied and used for other products. At the same time, when each checkpoint is reached, if incremental achievements

are reached an output is sent to the project and sales team, and at the same time an input is taken from the "lessons learned" coming from the projects. On this matter, the process that defines the way the department interacts with the projects has to be formalized to increase the efficiency in the transmission of information to reduce the risks that the investments will bring to non-profitable solutions.

3.5. Tools

In the previous chapters the process and organizational structure of the projects in the Telecom industry were presented, underlying how complex the procedure is, how dynamic the environment is and how spread the organization can be. The process involves in fact a cyclical progress with several steps that vary depending on the type of project that is being carried. At the same time, the fact that the process is cyclical and that the schedule of the complete project is not decided in the planning but through weekly meetings, means that the environment in which the project acts is continuously changing. Lastly, the organization is not concentrated in one place as the rollout is carried out by regions, while the controlling stays in the headquarter. For this reason, to enable an efficient work, there is the need for systems and technologies that provide the information infrastructure, the communication planning and the management planning with a standardized workflow that reduces the complexity and requirements for operational skills. These tools allow logically link all the phases of the project, to reduce the costs of the project, as less resources are required and the forecasts and analysis are more precise, and to increase the efficiency of the productivity, as the communication and coordination between the different teams is facilitated through the standard. If the tools are correctly chosen, deviations will be predicted in sufficient time to ensure that corrective actions can be applied to prevent that undesirable results occur.

In the past, project managers could count only on procedures to improve the efficacy of the forecast of the project, and thus the terms included in the contract, and to increase the chances of achieving the goals established. However, nowadays, thanks to the advances made in the IT industry, there are several software in the market that allow to have comprehensive and integrated packages, which provide tools, such as timesheets, reports or resource management, to boost the efficiency of the project. These software enable organizations to plan and control every project in with an integrated system that links each stage of the project and its functional areas, and provides all the necessary information to correctly handle the project. Of course, the software is only an enabler, while the main focus is on the methodologies that can be applied, which, in this industry, mainly regards five aspects:

- Work Breakdown structure (WBS) and matrix of responsibilities,
- Scheduling,
- Budget and cost control,
- Resource allocation,
- Risk management.

Through these it is in fact possible to increase the chances of success of a project, as all the team members are constantly able to evaluate and manage the progress of the project, controlling if the scope of the work corresponds to the defined WBS, estimating the timing and costs variances based on the forecast and thus changing the allocation of the resources to improve the result of the project, all having in mind the risks defined. It is however important that the project team does not

make the software take the lead, thinking that their tasks and attention can be lowered, but use it as a support that provides information that accelerate the work flow.

3.5.1 Work Breakdown Structure and Matrix of responsibilities

The scheduling is a very important phase of a rollout; however, as mentioned in the previous Chapters, in the telecommunications' world, the forecasting of the schedule is very hard to carry out in a precise and detailed way, since the order in which the sites will be built is not known in the early stages. Therefore, it is important to have some tools that allow to define the overall project, facilitating the update of the schedule once more information is added.

The first tool used is the Work Breakdown Structure (WBS), a procedure that aims at breaking tasks into more manageable units, each of which identified with a task required to fulfill part of a project, generating a hierarchical decomposition that defines the total scope of the project. The WBS is the first step to developing a better costing, scheduling and resource planning procedure as it allows to align the vision of all the stakeholders, providing a commonly shared and understandable project scope, and then dividing the deliverable into smaller, more manageable components. In fact, in this industry the projects are complex and with lots of activities, which means that without organizing the activities into a shared plan, the communication within the members of the project and to the external environment, would be more difficult.

A WBS of the projects of the telecom industry was presented in Chapter 3.3.3, where its importance was underlined, stating how it represented the basis for the development of the responsibility matrix, the cost estimation, the scheduling, the monitoring and the risk analysis. The reason why the WBS optimizes the following procedures is that, by decomposing the project scope into independent work packages, it enables to clearly identify the attributes connected to each and to increase the success of the implementation. Activities and work packages are identified with numbers; in this way, same activities in different projects can have costs and schedules pre-set by software, together with accounting systems for billing and revenue trigger. It was already mentioned how costs are not a leverage point in the construction telecom industry, as items and activities have a standard price and thus the price of a site is fixed (with cupping taking place only in special cases). By connecting the project activities to numbers, it is therefore possible to associate to the number a cost code, which accelerates the process of cost association and reduces the number of mistakes. In fact, the number of orders of new sites that a Vendor receives can be higher than 100 per day, per project, which means that if the purchase office had to take care of different costs per similar activities the process would be very time consuming and with many mistakes.

Although there are several types of methods of decomposing the deliverable, in the telecom projects the logic with which the WBS is developed is, first the types of projects, then the processes and then the BOM (bill of materials), which represents the disassembly of the deliverable into its subcomponents. The reason why a process-oriented WBS is preferred over the deliverable-oriented, is that it ensures that all the processes are included in the solution, reducing the risks of having tasks that are left off the sheet. Moreover, the costing estimation per single site does not have a high variability, which gives more importance to first define the process, compared to first defining the items required.

The main impact that the WBS has is over the matrix of responsibilities, ***Figure 37***, a matrix that identifies the owner of an activity or work package. Depending on the portion of work scope

the owner or resource required will be different, going from phases where technical engineers are needed, to phases where procurement capabilities are more required. Through the matrix of responsibilities it is thus possible to decompose the human resources, identifying the number of resources and the competence area necessary for each activity. The idea is that each activity presented in the WBS must have an owner and an estimated workload necessary to perform the activity to promptly identify the responsible person in case of issues or changes that arise during the implementation. The projects have in fact a high variability and are impacted by frequent changes, which means that it is of extreme importance to know who the responsible person of the task is.

	Item	Provided by	
		Vendor	Customer
1.	**Delivery of Equiptment**		
1.1	Delivery of equipment, documentation and tools according to the contract	R	
1.2	Customs clearance		R
1.3	Payment of customs duty and other local taxes		R
1.4	Deliver from customs to warehouse		R
1.5	Warehouse mgmt	R	
1.6	Deliver from warehouse to site	R	S
1.7	Unpacking at site and disposal of wastes	R	
1.8	Packing and deliver swap equipment to customer warehouse	R	
1.9	Inspection of the swap equipment	S	R
...		R=Responsibility S=Supervisor	

Figure 37 - Matrix of responsibilities: Vendor vs. Customer

3.5.2 Scheduling

Scheduling is one of the main tools used in project management as it allows to determine the expected opening dates of the project, the expected dates in which milestones are reached, and the expenditure estimates per period. The scheduling is often used as a communication tool both internally within the project members, and externally with the customer; in fact, when it is well-done it gives an idea of the progression of the project, underlying where there were activities that went wrong and who is responsible for a delay or an increase in the costs.

However, in projects concerning the telecommunication industry, changes that affect the scheduling plan happen often, which makes it complicated to have an accurate planning since the early stages of the project. Moreover, while the WBS, which describes the decomposition of a site, is stable with just minor differences between the sites that will be built, the scheduling depends on the number of sites that are under construction and, as mentioned several times over the elaborate, this is an information that is not defined in the contractual phase. A contractor normally establishes the impact, in terms of coverage and capability, that he is expecting from the contract, while the

precise number of sites that will be required will depend on several other variables that are known only when the detailed design of a site is implemented. Therefore, an overall scheduling, described in the Master Plan is available since the early stages, but a more precise and detailed scheduling is processed on a monthly, or even weekly, basis when an overview of the number of sites that will have to be built is given by the customer. For this reason, a lot of attention is given to the availability of the resources and material, which represent the bottleneck of such an unstable scheduling process.

The Master Plan is under the form of a milestone chart to ensure that the key points of a project are reached at expected times. In fact, the projects have to meet a time schedule, where the customer is expecting to launch the new technology, and to ensure that the project is one-time, milestones with capacity and coverage checks are set over the time period. The Master Plan is defined based on the High-level design (HLD), which, as presented in Chapter 3.3.2, defines the overall architecture based on the service required. Through the HLD it is in fact possible to have a blueprint of where the coverage has to be increased and of how much and thus understand how many sites will have to probably be built in the area. These milestones will then work as checkpoints to monitor the progress of the overall project. Together with the major milestones, the Master Plan provides also the duration and costs associated to the tasks that have to be performed when building a site, and the number of resources required per type of activity. The Master Plan is thus defined based on three information:

- Dependencies between project activities,
- Dependencies with organizational activities,
- Milestone plan based on customer's request.

Representing and organizing the activities of the projects in this industry is very challenging as, on one hand, the activities are cyclical and standard, on the other, the project have a massive coverage in terms of geographical expansion and number of sites, and a high unpredictability of the number of sites that will have to be implemented. Representing the evolution of the project through a Gantt chart[5], does not bring any advantage; the number of sites would in fact make the chart hard to visualize and interpret, not being of any help for the planning, coordinating or controlling phases. Moreover, the Gantt chart only allows to visualize the timing of the tasks that have to be completed without providing information about the dependencies between the activities. Therefore, since the timing of the activities is not known, to provide more accurate information, still allowing to visualize the progression of the project, a Network Diagram is used. The Network Diagram uses linkages to show the chronological sequence of the tasks according to the dependency defined by the process. Normally, to simplify the view, several versions of the Network Diagram are provided by the project team; one representing the major milestones of the project, and the others illustrating the sequence relevant to the pertinent domain and department. For each Network Diagram, the most important nodes are normally highlighted with a different color to facilitate the visualization of the key points. Each node of the Network Diagram represents an important activity that has to be performed to successfully complete the project and is defined through four information:

[5] The Gantt Chart is a time chart devised by Henry Gantt in 1917 to increase the efficiency in choosing the order of the operations by representing the timeline of a project through horizontal bars. Through the task bars, milestones markers and duration of the tasks, Gantt charts proved to be powerful analytical tools for managers.

- Name of the activity
- Planned and actual start
- Estimated duration
- Name of the owner of the activity

Through this information the project team is in fact able to monitor the progression of the project and the accuracy of the forecasts, by analyzing the float between the planned and actual dates, identify the responsible person for the issue, and through the sequence of dependent tasks understand which activities will be affected and how to face the delay.

To facilitate the production of a Network Diagram there are many software that can be used, one of the most common is Microsoft Project[6], which allows to represent the introduce the WBS, CBS and OBS of the project, to then proceed with assigning the resources and costs to the activities. As resources are assigned to the tasks and the estimation of the duration of each activity can be introduced in the software, once the sequence has been created, it is possible to visualize an automatically generated Network Diagram, including the features presented above.

To estimate the duration of the activities a PERT[7] (Program evaluation and review technique) technique is used. The PERT is a statistical tool that allows to calculate a more realistic duration of a task by taking into consideration the uncertainties and looking at three different duration estimates:

- Optimistic (a): the duration of a task if all factors go in favor of the project;
- Pessimistic (b): the duration if all goes wrong;
- Most likely (m): the duration that includes the major issues that could occur.

The reason why the PERT method is used, is that, due to the complexity and high uncertainty that the projects in the telecom industry can have, it allows to define a more realistic estimates of the duration as it takes into consideration several issues that can be faced during the implementation.

The realistic duration of a task, assuming that the activity is normally distributed, is calculated as:

$$\bar{d} = \frac{a + 4m + b}{6}$$

Where a is the optimistic estimation, b the pessimistic estimation, and m the most likely estimation, reason why m is multiplied by a factor.

In the telecom industry the environment is in constant change and according to the contract, the demand of sites is not established since the signing of the contract, when only general values are known, but the customer has to provide a delivery volume forecast one month before each quarter, in order to provide enough time to the Vendor to adapt the resources correspondingly, and a precise number of sites requested for each month; however, the actual volume of each month has a lot of

[6] Microsoft Project is a tool, part of the Microsoft Office family, originally created for the IBM PC in the 1980s. The trigger of its implementation was the increase in the complexity of the projects together with the shrinking of the available time to plan, which required a tool that assisted the project manager.

[7] PERT is a statistical tool that was developed in 1957 to support a nuclear submarine project, developed by the U.S. Navy during the cold war, to analyze and represent the tasks involved in completing a given project. Through this tool it was possible to represent the major events essential to achieve the objectives, the inter-dependencies between those events, and the estimates of time necessary to complete the activity.

variations depending on the Region and type of site, ***Table 3***. Which means, that there are teams that are very free and teams that are super busy and that the Vendor is thus not able to always fulfill the requests of the customer.

Table 3 - Scheduling forecast Planned vs Weekly baseline

	I&C Planned	I&C Baseline	GAP	RFS Planned	RFS Baseline	GAP	TIS Planned	TIS Baseline	GAP	RFC
CW 7	55	52	3	53	55	-2	20	33	-7	11
CW 8	52	52	0	52	51	1	27	40	-13	0
CW 9	33	45	-12	75	63	12	22	42	-20	0
CW 10	31	42	-11	57	60	-3	30	41	-9	0
CW 11	26	28	-2	71	65	6	98	49	49	0
CW 12	22	20	2	67	62	5	92	44	48	0
CW 13	15	#N/A	#N/A	0	#N/A	#N/A	0	#N/A	#N/A	0
CW 14	7	#N/A	#N/A	8	#N/A	#N/A	0	#N/A	#N/A	0
TOTAL			-20			19			48	

TIS Target	**2051**
Current Total	1533
GAP	- 518

Planned: has actual or plan date in CW X
Baseline: weekly baselin
GAP = Planned - Baseline

As the demand forecast is not defined for the whole project, but updated on a monthly basis, if the forecast of the sites' implementation was carried in a traditional way, the uncertainties and the high volatility of the requested number of sites would have a negative impact in the output; therefore, the forecast is of a rolling type. In this way, the Vendors can be more dynamic in adapting to changes.

Even though the rolling forecast was originally created for the manufacturing industry, it also fits the network implementation as also in this case the demand is not known, but the implementation is still based on factors that have limitations, such as the number of resources available. The idea is that, since the business is not based on a static demand, by embracing continuous planning and having a higher degree of flexibility, the Vendors are more agile and able to fulfill the internal and external expectations, constantly revising and updating the plan based on more precise information and thus helping managers to focus on the important points of the project, allowing the resources to be allocated based on the updated conditions. At the same time, through the information coming from the updates, it is possible to understand which are the critical points faced in the implementation plan and take thus an action to try to solve them. In fact, rolling forecasts are not simply periodic updates against the forecasted annual demand to fill the gap and meet the target, but are opportunities to better foresee the future and adapt to the dynamic environment by ensuring that who makes the decisions has a more accurate picture of the present condition.

When implementing a rolling forecast, three pre-conditions are of extreme importance:

- Understanding the reason why a rolling forecast is required. A mistake that a company can make is in fact to start using the rolling forecast in all the business areas. However,

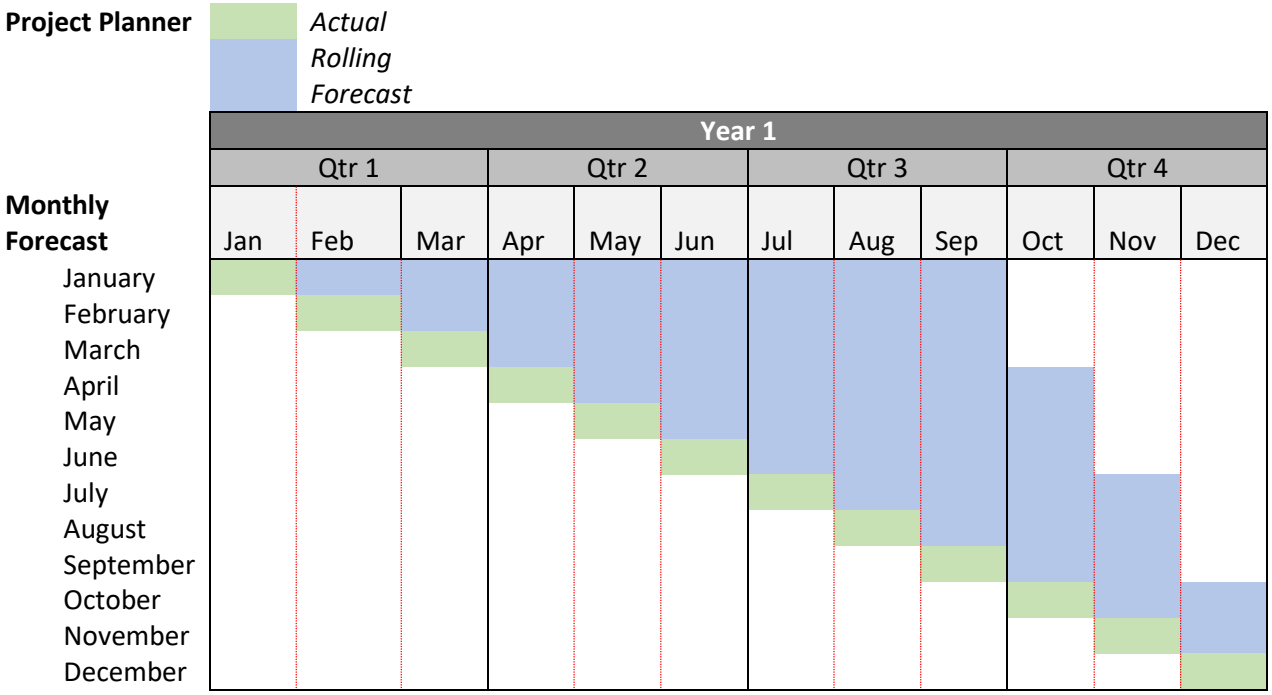
the rolling forecast is not appropriate for all the types of plan and the Vendor should focus only on drivers that are relevant for the decision-making. For example, in this industry, if applied to the supply chain forecast it would over complicate, and increase the costs of, a process that can be carried with long-term annual forecasts.

- Identifying the correct forecast duration of the project. The timeframe selected for the forecasts updates has to be consistent with the business cycle. In this case, the demand of sites to be implemented comes from the customer on a monthly basis and therefore, the chosen duration for a new forecast is one month. However, in order not to overcomplicate the re-forecasting, at the tail of the project an update is made only at the end of each quarter. This has the benefit of increasing the precision in the short term, without wasting time on months that are very far away. At the same time, it is also important to know which is the duration of the whole forecast, which in this case it is very simple as it is based on the duration of the contract, which normally is one year.
- Identify the correct comparison periods. To analyze the output correctly, it is firstly important to decide the combination of columns to compare that fits the project. The sales and the budget are analyzed on a project lifecycle basis, which means annual, while the scheduling rollout is analyzed on a monthly basis providing a comparison between the plan and the actual results. Over time, thanks to the reviews, the project team realizes which predictors being used are inconsistent and which provide a good forecast and can thus be used as KPIs for goal setting.

In the rolling forecast, the implementation annual plan is made assuming a demand forecast, in this case based on the capacity and coverage plan established in the contract; however, since the data input is imprecise and unstable it would be of no sense to establish a defined schedule for the whole project. Therefore, at the beginning of each month, when the demand of the customer is known, the first period of the plan is implemented by releasing the resources that are necessary to fulfill it. The monthly plan is reviewed on a weekly basis to adapt it based on the resources level and on the progress in the implementation; in fact, it could happen that some sites encounter issues that delay their implementation.

In the industry analyzed, the tool used for the forecasts is Excel, ***Table 4***, which however does not suit the situation and the goals that want to be achieved. In fact, Excel spreadsheets are hard to keep up to date, especially considering that in the rolling forecast there are several forecasts being carried at the same time. To optimally carry out a rolling forecast it is necessary to run different plans in parallel to perform variance analysis and to understand the impact of the alterations to the plan. All these functions are not supported by Excel, which, as presented in Chapter 4.7, pushes in the direction of creating a system that can provide the necessary functionalities.

Table 4 - Rolling Forecast



In the telecom industry, for the fulfillment of the scheduling forecast the number of resources available is the strongest constraint. For this reason it is important that the Vendor has under control the number of resources that each partner the has for each time frame, ***Table 5***, in order to understand if the number of sites demanded by the Customer can be fulfilled, and if a potential failure is forecasted on time, alternative solutions are provided.

Table 5 - Partner Resources Forecast

Partner Resource Forecast													
Region	Partner	CW 1		CW 2		CW 3		CW 4		CW 5		CW 6	
		Plan	Capacity	Plan	Capacity	Plan	Capacity	Plan	Capacity	Plan	Capacity	Plan	Capacity
North	A	5	5	2	5	5	5	5	5	5	5	7	5
	B	4	4	5	4	6	4	6	4	6	4	4	4
	C	5	6	6	6	4	6	4	6	4	6	4	6
	Total	14	15	13	15	15	15	15	15	15	15	15	15
South	D	6	5	4	5	4	5	4	5	4	5	4	5
	E	4	5	5	5	5	5	5	5	5	5	5	5
	Total	10	10	9	10	9	10	9	10	9	10	9	10
West	B	6	3	5	3	2	3	4	3	4	3	4	3
	E	3	6	6	6	5	6	4	6	4	6	4	6
	Total	9	9	11	9	7	9	8	9	8	9	8	9
East	F	7	6	6	6	5	6	5	6	5	6	5	6
	A	0	0	7	8	7	8	7	8	7	8	7	8
	Total	7	6	13	14	12	14	12	14	12	14	12	14
TOTAL		40	40	46	48	43	48	44	48	44	48	44	48

To facilitate the visualization of the number of resources available against the delivery forecast, Resource Diagrams are used. In fact, through resource diagrams it is possible to graphically represent the number of resources available and the number of resources in use, increasing the simplicity and efficiency of the allocation and the shifts of resources between sites. The reader must bear in mind that in the case analyzed, the resources that are kept under investigation are the partners, as they are the main figures responsible for a timely delivery of the sites.

In the market, there are several tools that offer the opportunity to create resource diagrams with features that increase the rapidity in the understanding of the graphs. The most used software is once again Microsoft Project, which provides different outputs:

- Resource Usage: it is a view that allows to monitor the status of the usage of the resources, highlighting if there are overallocations and supporting the leveling of the resources in order to prevent the case of having one partner overallocated and one free.
- Capacity planning: it is a function that facilitates the shifting of resources across different sites, regions, or projects. This view is particularly used in the business since site shifts between partners that operate in the same region are quite common, as well as sharing of resources of the same partner across different projects. This is due to the fact that the number of partners, and especially the ones that are considered as reliable by the Vendor, is not that high.
- Resource Graph: the resource graph is a bar chart that shows the availability of a singular partner resources across the phases of the site implementation. Through this graph, ***Figure 38***, the project manager is able to quickly understand if the selected partner is over or under allocated and in which particular phase.

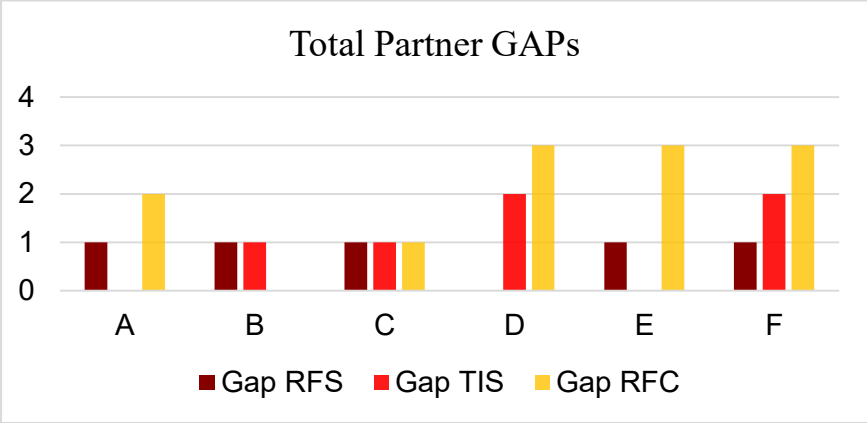


Figure 38 - Partner Resource Chart - GAP analysis

3.5.3 Monitoring

At a project management level, the monitoring is the most important phases; in fact, to ensure that the project develops in the right direction, that unforeseen circumstances are avoided, and that mismatches are corrected on time, the project manager and his team have to constantly monitor the progress of the project compared to the overall goals and timeline.

The monitoring phase has to be planned by the project team by defining a procedure for the collection of the information and by choosing the appropriate indicators. In fact, in order to avoid wasting time in controlling factors that are not of great importance for the project objective, the project manager has to carefully choose the indicators that will be kept under control. These, have to be:

- Effective, and thus produce a successful output, by "doing the right thing", that has an impact on the delivery of the project;
- Efficient, which means that the indicators have to produce an output without wasting materials, time, or energy, which is resumed with the concept of "doing the thing right" by choosing indicators that are pertinent.

In fact, if the indicators are well designed and picked, they can have a positive impact in the communication with the stakeholders, as a good monitoring provides good reports with data analysis, and can be used to measure the results obtained during the implementation and the impact in the objective of the project, being then used as data for future strategic planning. The monitoring can then be used both with a coordination and with a controlling function; the coordination is achieved by allowing a smoother and more efficient communication between the parties with more reports and feedbacks prepared through less effort, the controlling is assured by the checking the progress of the project and re-programming the activities in case of problems found.

Part of the indicators are used to control the status of the project against the yearly goals and, in the network rollout, are thus used mainly to do financial estimations about the amount of budget that was consumed and the revenue that was made, compared to the costs that are carried, measuring the cost to date and the cost remaining. These indicators are measured on a monthly basis. Due to the fact that the schedule is not planned in advance, it would not make sense, and there would not be also the availability of data, to compare the number of sites built with an annual or project forecast. Therefore, for the schedule progress, the indicators are compared daily against monthly goals and are applied on a more frequent basis. While the resources, as mentioned in Chapter 3.5.1 are recorded in terms of partners resources available per week compared to the effort remaining.

To monitor the evolution both of the schedule and of the costs Microsoft Project is used. The reason why this tool is employed is that it is important that the project is managed on a stable platform, widely comprehended and with fewer problems and bugs to solve. However, there are several functions that MS Project does not support, reason why in the new model proposed the basic idea of a new tool will be described. In terms of monitoring, through MS Project, it is possible to have the milestones and checkpoints under control and, if deviations are shown, apply corrective actions.

To measure the forecast of the project cost and time, two variance analysis methods are used:

- Earned value analysis (EVA), a method that integrates cost, schedule and work performed by associating a monetary value to each to measure and forecast the final cost and time of the project. Through this procedure it is thus possible to determine the real gains or losses.
- Variance impact analysis: procedure used to analyze the impact to the subsequent activities and to the general budget if the identified variance, identified with the EVA, is not corrected.

The key values of these analysis are three:

- Planned value (BCWS), which is the planned cost for the work during a certain period of time. The PV is given by the product of the quantity of work that was planned and the cost of the work.

$$BCWS = Budget\ Cost\ x\ Work\ Scheduled \qquad (3.1)$$

- Actual Cost (ACWP), which is the cost that actually incurred to achieve the work during the time period. The AC is calculated as the quantity of work that was performed times the actual cost that was hold to complete the work.

$$ACWP = Actual\ Cost \qquad (3.2)$$

- Earned Value (BCWP), which represents the cost of the actual job performed within the time period, if the budget was as planned. The EV allows thus to valorize the work performed to understand the schedule variances highlighting if the project is on time or delayed, and if the costs are as forecasted or higher or lower.

$$BCWP = Budget\ Cost\ x\ Work\ Performed \qquad (3.3)$$

The reason why these values are introduced is that a traditional comparison between the actual and budget costs would fail in providing a significant output, as the budget spent depends also on the work that was performed. Through these variables, the project team is thus able to formalize some performance indexes that allow to analyze the cost and time progress. These are effective and efficient indicators that can then be used to produce reports and reviews to communicate to the stakeholders the quality of the progress and to take measures in case the index is not as desired.

The indicators that are mostly used are:

- Cost Variance, CV = BCWP – ACWP, which if < 0 indicates a cost higher than expected, while if > 0 it represents a saving.
- Cost Performance Index, CPI = BCWP / ACWP, which represents the efficiency over the costs, values > 1 indicate that the project is less expensive than expected.
- Schedule Variance, SV = BCWP – BCWS, which indicates how much of the work expected for the time frame was completed, which if < than 0 indicates that the project is running late.
- Schedule Performance Index, SPI = BCWP / BCWS, which indicates the efficiency over the time, which means that a value > 1 indicates a time of completion lower than planned.

Once a variance in the performance, either in terms of time or costs, is identified, the project team has to analyze its impact to make the proper decisions. Concerning the cost variance, if the project is more expensive than expected, it could mainly happen for two reasons: the site required more work than expected and additional costs were thus necessary, the customer was allowed to use the so called “vouchers”. Regarding the first case, it could in fact happen that the design has to be re-made due to a rejection of the authorization, or that, once on site, the engineers realize that more civil works are required to stabilize the site. In this case, as mentioned, the contract establishes that up to 10X% (normally between 130-150%) of the costs are born by the Vendor, while the exceeding ones are on the Customer; therefore, if the CPI highlights exceeding costs, the percentage will determine who will have to bear them. For what concerns the vouchers, these are cost reductions that the financial team gives to the customer, either to support a good partnership in its bad time, or to compensate cost sharing issues that were encountered during the project. Of

course, the presence of the Vouchers, which are a price reduction for the item/service, brings to a CPI < 1.

Concerning the SPI, the scheduling delays are mainly analyzed to monitor the progress of the project and to understand if the goals and site requests coming from the customer at the beginning of the month are realistic or not. In fact, as mentioned several time, in the telecom industry the scheduling is decided on a monthly basis, but also the schedule of the month can vary due to problems encountered when building a site or environmental issues (like bad weather conditions). For this reason the SPI tends not to have a linear output and is not used for scheduling rectifications, but for the trend analysis to increase the precision in the scheduling planning and in the risks identification.

In some special cases the customer requires the scheduling to be on time, this normally happens when the end of the financial year is approaching and the customer wants to consume the budget that was allocated to the project. In this case, to accelerate the project, the PM can invest more money on subcontractor resources (as only with more resource the sites can be built in parallel), speed up the delivery schedule by ensuring an efficient logistics department that delivers the materials in good conditions and on-time, or improve the subcontractor efficiency through trainings.

One last indicator that is strictly monitored is the status of the deliveries in terms of deliveries on time and location of the delivery. In fact, as mentioned in Chapter 3.3.2.3, it is very important that the right material is delivered at the right time, action that is made difficult by the number of changes in the delivery location that are made. This happens especially when site shifts are necessary, and material is transferred from a different location than the expected one. If the transfer of items is not correctly monitored, disputes between the Vendor and the Customer arise bringing to many costs in terms of time spent on reviewing and money, when the dispute cannot be solved.

4. Critical Evaluation

During the analyses of the world of a telecom company, going through its process, organizational structure and tools and methodologies, some critical issues that decrease the success rate and that increase the costs, reducing thus the profits, were encountered. Especially when looking at the direction in which the telecommunication world is going to, these have to be evaluated and an optimized solution that brings improvements in terms of process, organizational structure and tools has to be provided, becoming a source of competitive advantage and success.

To facilitate the understanding of the critical issues that were encountered, these are divided based on the macro-categories that characterized the structure of this paper. Focusing first on the process, then on the organizational structure, to end with the tools.

4.1 Process

When looking at the process, the temporal structure is something that cannot be changed; in fact, the order and relation between the phases depends on governmental regulations that cannot vary, or on technical requirements that are defined by the technical team and that represent a constraint. What is thus not properly working about the process, and can be changed, is not the sequence, but the way in which some stages are handled. This is mainly true for:

- The definition of the project scope in the early stages;
- The risk management activities.

If we look at these two critical issues, it is already possible to understand how complicated it can be to provide a new solution; in fact, change and risk management are both problems that require a complete new methodology and way of looking at the project.

Change, is one of the main words that is most used throughout the company lifecycle; changes happen constantly, and even though the project team is aware of the fact that the project is not stable, changes are eventually still a problem that the team is not able to correctly face. The reason behind this high number of changes is that the customer does not decide on the solution to implement for each site until it has not decided that a site will be built, which, as explained in Chapter 3.5.2, happens on a quarter basis. Delays in the decisions and modifications coming from the customer imply that the TMO is constantly working on new solutions and that the design team is not able to provide the LLD in advance, afraid that a modification could nullify their efforts, and that third parties acceptance procedure is thus delayed, postponing the beginning of the implementation. Changes cannot be avoided, however in order to improve the results, the project team has to change its mentality, based on waterfall and defined procedures, adapting to a new methodology that follows Agile approaches, which train the project team to be more flexible and ready to face changes.

Each type of site has a different process, duration, and number of resources required and, without a proper forecast, it often happens that there are overlays and that the team is not able to respond to the implementation forecast, decreasing the chances of delivering the sites without delays in the rollout. Externally, lags caused by changes are related to the lack of partner resources, problem that cannot be solved as the number of partners that are trusted both on the Vendor and on the Customer side is limited, reason why this issue will not be considered in any of the further

analysis. Internally, this brings to a problem especially concerning the delivery of the material; in fact, without precisely knowing when the site will be implemented, the supply chain team has to deal with a low accuracy of the material-on-site (MOS) date, which leads both to an increase of the costs due to overstocking, in order to have more material available, and to a slower installation process as a slack time for the delivery of certain types of high-value material is required. At the same time, since non-used material is in the warehouse, constant site shifts are applied, which increase the complexity in the tracking process.

Concerning the scope, apart from the changes, a factor that is not well managed is the acceptance process. In fact, currently the Vendor faces several delays in the FAC procedure due to missing documentation or smaller issues that to be solved would need partner resources. However, as mentioned, partner resources are mostly over-occupied with the normal rollout and they do not have time to solve quality issues. This has a strong impact in the return of the project, as 20% of the payment pends on the FAC acceptance document and therefore should be treated as a major issue to solve; which could be achieved by providing tools that support the provisioning of documentation and accelerate the quality control process from the customer.

When looking at risk management, what comes to head is that there is a lack of risk management procedures implemented throughout the project. In fact, even though risk management is a mandatory element and a procedure is theoretically defined, the process is far from smooth and the project team has to face a series of requirements without having a strong methodology that adds value to the project. Moreover, while in the early stages, where risks have to be identified, the project team has more time and is thus able to look more carefully at the identification of the risks; during the implementation, as time shrinks, risk management is less and less taken into account. It is thus important to define a more structured procedure and especially tools that facilitate the implementation of risk management throughout the whole life-cycle.

4.2 Organizational Structure

The organizational structure has problems related to the fact that, even though the organization is project-based, the organizational structure is a lightweight matrix that does not provide enough support to the project team. As a consequence, functional, or line, managers have more decision power compared to the project management team, which impacts both the ability to react to changes and the relationship with the customer.

Concerning the first point, the functional resources that are shared between several projects respond firstly to their line manager and then to the project manager. This has two negative effects on the project: the project is less flexible and less ready to react to changes, and the functional team focuses more on the functional than on the project KPIs. Changes come from the customer through the Project Manager, but the PM is not able, or at least not in a quick way, to make the functional team react and adapt to the new requirements, which means that it often happens that the PM accepts change requests that are not feasible at a functional level. At the same time, the lack of definition of the responsibilities brings to a confusion of who the owner is when issues occur and when critical situations are faced, creating both delays and a bad impression to the customer.

On the other hand, looking at the relationship with the customer, the lightweight matrix does not fit the organizational structure of the customer, which is normally of a strong matrix type. This means that the communication is slowed by roles and responsibilities that do not match and that

the single point of contact for the customer is the project manager, who as mentioned has less power and control over the resources compared to the line manager. The lack of communication between the parties has a strong impact especially in the rollout phase, where the customer provides unrealistic delivery expectations due to a low understanding of the problems that the Vendor has to face.

4.3 Tools

The tools, which are currently based on the use of Excel sheets and several platforms that do not communicate, slow down the integration process and the sharing of information within the team and with the customer. In fact, the lack of real time communication, in an environment where changes are a main actor, implies that the project team is constantly one step behind the real estate of the project. Of course, in this matter, changing the IS of a company is a very complex and long process that has to be carefully analyzed to understand until which extent it will bring more advantages than disadvantages.

Looking at the pain points, these can thus be resumed into four macro-categories depending on what the issue is related to, being this: change, organizational structure, risk, tool.

Before providing a deeper analysis about a new model that aims at solving these pain points, it is important to also understand what are the pain points of the customer and how they, in most of the cases, match the ones of the Vendor. In fact, if a company wants to survive in the market without being overcome by other competitors, it has to yes solve its internal critical points, but especially prove to the customer that through their way of managing the work, they can solve the pain points of the customer itself. This is achieved by providing a process and tools that strengthen the relationship with the customer, ensuring that the goals that the two companies are looking at match. When looking at the side of the customer, this has mainly five pain points, which have an impact on its profits either due to revenue decreases or costs increases:

- High costs of the service and hardware;
- Quality issues that bring to risks in terms of information security, communication quality, business continuity, and efficacy of the network;
- Slow rollout with market share loss;
- Lack of E2E ownership due to a fragmented responsibility;
- High number of subcontractors to manage.

The high costs of the hardware is not manageable by the Vendor, as the hardware produced are high-value material that require a lot of R&D, to be constantly updated, and a costly production that requires precision and handling of high value material. On the service side, however, the Vendor could achieve a lower price through a better defined process. In fact, one of the reasons behind the high costs of the service is the constant change that, since the service has a fixed price, impacts the overall price requested to the customer.

Quality issues are related both to a procedure that does not correctly support the quality control process and to a lack of control of the risks that lowers the final quality of the deliverable. Introducing a risk management process and at the same time providing a tool to support the quality process are both actions that could bring to benefits both for the Vendor and for the Customer.

Concerning the slowness of the rollout, as mentioned several times, to accelerate the delivery it would be required to have more partners. However, both on the Customer and on the Vendor side, increasing the number of subcontractors is not considered an option as it implies increased complexity, increased chances of having quality issues, and increased costs due to more control required in the early stages. Even though the Vendor could not accelerate the rollout, through an organizational change, it could improve the communication with the customer increasing the alignment and the sharing of pain points.

4.4 Providing a new process that follows Agile Methodologies

When looking at a new model, one of the main risks would be to provide a new methodology without having a strategy behind it, which would bring to a series of solutions that do not support the real needs of the team or that do not suit the goals of the project. It is thus important that the approach to a new methodology is strategically evaluated, as putting together the best tools does not always ensure the success in the long-term, and the aim of a company is not to win only a battle but the whole war.

To develop an approach that follows the strategy of the company, several points have to be taken into consideration:

- The environment in which the company acts. In fact, there are general conditions that facilitate or obstruct the life-cycle of the project, impacting the importance that is given to certain phases of the project. For example, if the economic conditions are bad or unstable, the focus on cost control procedures is higher. In the case analyzed, the general environment is quite stable due to the constant growth of the telecommunication market and its importance for the other industries that are starting to depend on it for their new technologies, which means that the environment does not impact the changes proposed in the new procedure.
- The customer environment. In fact, the client is what brings profits to the company and therefore its environment has to be carefully analyzed when defining the most important phases, to understand their impact in the priorities of the project. In this case, the surrounding environment is in constant change and growth, which brings a high focus on the speed and quality of the output. The Customers are in fact interested to be the first, among their competitors, with a new working technology out in order to increase their market share; therefore, Vendors need to learn how to react to speed and changes without forgetting quality.
- The tasks complexity and uncertainty. This is a very critical point, as usually different areas of the organization will evaluate a task in a different way. However, it is important that the complexity of the task is identified to understand the extent to which it will be important, and the amount of communication and coordination that it will require. At the same time, the complexity has to be evaluated to understand how important it will be to introduce tools that support the activity.
- The success criteria have to be defined. In this case, as the company works on external projects, it is the Customer who defines the criteria with which the projects are evaluated, being these *time* and *quality*. Costs are of course important, but are more controllable as they are fixed (per site) since the bidding phase of the project and can thus be controlled by the customer by deciding how many sites will be implemented. Time and quality are what

have the greatest importance as they impact the customer satisfaction and the chances for the Vendor of winning the biddings of more projects.

Even if a methodology is defined following these principles and thus aligned with the strategy, the process will not be effective if it is not accepted by the people that have to work with it. When deciding to change a way of working inside a company, it is in fact important that the team is committed to the change and that it understands the benefits that will come with it. If this fails, the integration will not be effective and the new approach will bring more problems than benefits. To avoid this, it is important to involve the project members in the planning to understand what the true pain points are and to make them feel as part of the change, and thus leaders in pushing the approach to the rest of the team.

For as simple as it may sound, many times project teams are so focused on looking at specific problems that they forget to define a procedure for the normal scenarios, making it then reactive to changes and issues. The new model should thus focus on three main points:

1) Starting it right,
2) Executing it right,
3) Closing it right.

4.4.1 Starting it right

Starting it right is about enhancing the analysis and establishment phases of the project where the technical solution and design are decided, which both have to be carefully examined in terms of return and efficiency before they are proposed to the customer. In fact, with the changes that come during the life-cycle of the project, in order not to increase the complexity, the technical side has to be well defined and the available solutions described. In this way, once change requests come, the project team is facilitated in understanding if the requested output is feasible or not.

When looking at the delivery process in the case being analyzed, the main issues in the project establishment, where the organization is set, the project plan is reviewed with the project team and the targets are set, is the lack of internal communication. In fact, if you talk with the delivery project team, they will most certainly tell you that all the problems of the project come from the sales team, who defines non-feasible terms in the contract with the Customer. However, since in the establishment phase there is still margin for modification, if more effort was put by the project team, when the solution is handed over, the impact of bad decisions coming from the bidding phases would be lower.

It is important to recognize that in this phase the agile methodology is not applied; what changes is that, to facilitate the application of a more flexible approach later on, the project goal is divided into smaller components; in this way, the execution will focus on the most important iterations first, leaving the least important to the end. This could easily be applied to the business by clearly defining in the bidding phase the priority of the regions. A Vendor working on an expansion in a country, would first divide the country into regions, and then the regions into clusters with a priority depending on how important the expansion of the network in the cluster is for the customer. This concept is already used in the business, but further in the process, which means that in the early stages the project team does not have an overview of the overall priority of the clusters. By introducing the priorities already in the early stages, the benefit is that the partner resources can

be planned and forecasted more precisely, increasing the chances of developing a rough schedule close to reality and giving more data to the project team to facilitate the decision on how to react to a change, knowing what will come. Through the priorities, to then facilitate the planning phase, reducing the number and impact of the changes, an action plan has to be carried:

- Establishing a corporate audit that assesses the manpower, finance and technology available to determine what will be available for deployment during the project;
- The Corporate Audit plan has then to be adapted to be consistent with the market and the objective requested by contract.

It is important to bear in mind, that the current status of the telecom project is not related to unsuccessful projects that are not launched in the market, as the Vendor is always able to deliver the output requested. The problem is related to the inefficiency of the execution, which brings to delays in the closure of the project either due to delays in the project schedule or to quality issues that have to be solved. This is the reason why more importance is given on finding methods that could positively impact the execution and closure of the project, rather than changing the starting stages.

4.4.2 Executing it right

Executing it right is about standardizing the process and pushing it into an Agile direction. The telecom industry has always been characterized by a traditional approach, which does not mean that the employees did not work in teams, or that teams did not collaborate with the customer and internally through recurrent meetings, but that the concepts behind the Agile methodology are not applied through a standardized process and therefore they are both not fully understood by the team and not used in a regular form.

As stated several times, the deliverable is unstable and constant changes are requested by the customer; this, together with the fact that the Vendors work on multi-projects and that therefore resources are not allocated to just one project, bring changes to be hard to handle, especially if they come late. To successfully execute the project in this environment it is thus important that the planning and implementation are constantly updated according to the current status of the project, and that the project team is continuously coordinated. Therefore, even though the Agile approach was developed mainly for the software industry, its procedures can be adapted to be implemented also to the construction industry. The harsh behind the application in this industry is that, since the Agile methodology is more a way of thinking than an approach with tools and practices, it involves a change in the culture of the organization, which is harder to apply when projects are characterized by a high number of resources, making inter-team collaboration harder to manage. In fact, the bigger is the number of team-members and departments involved, the more formal documentation is required, reducing thus the agility of the project, and the more interaction with organizational units that do not work with an agile approach is required.

What are thus the challenges faced when applying an agile transformation to a large-scale project? First the resistance to change coming from the people that work in the organization. As mentioned in the beginning of the chapter, a methodology that is not accepted by the people that have to work with it, is a failure. It is important that the management is thus able to correctly implement the transformation process, understanding what the reasons behind the resistance are and how to mitigate them. Normally the resilience of the employees comes from their being afraid

of changes of roles and responsibilities, with increases in the workload due to more cross-functional activities that have to be carried, especially in the transition phase, when new things have to be learnt, and with higher control due to more interaction with the other team-members and with the customer. This skepticism towards the new working method is often generated by a misconception of the agile methodology, thinking that frequent meetings will slow the process down and will bring to not having a plan. To implement the transformation in a smooth manner, the management has to avoid imposing the changes as a top-down request and put effort and money into training to reduce the workload required to understand the transformation and to increase the diffusion of the agile concepts within the company, avoiding that different interpretations are generated and that therefore different applications are created. This is true especially when the methodology is extended to the entire organization after a success in the pilot is demonstrated and once different teams have to be coordinated.

It often happens that when Agile is applied in a new project, its members think that the implication is that less documentation will be required and that activities can be carried in a more generic way; however, Agile is not only about flexibility, as it brings a procedure with it. The biggest mistake that can thus be made, when moving into an Agile direction, is to not adapt into the new procedure, but turn the process into a series of "*mini waterfalls*".

Even though introducing an Agile methodology, ***Figure 39***, could bring some challenges, if correctly applied, several success factors could be introduced, all going in the direction of being able to respond better to changes through a more flexible approach. In fact, through this methodology the process is more iterative and the continuous feedback coming from the customer, together with the continuous internal updates, allow to positively face the variability of the project.

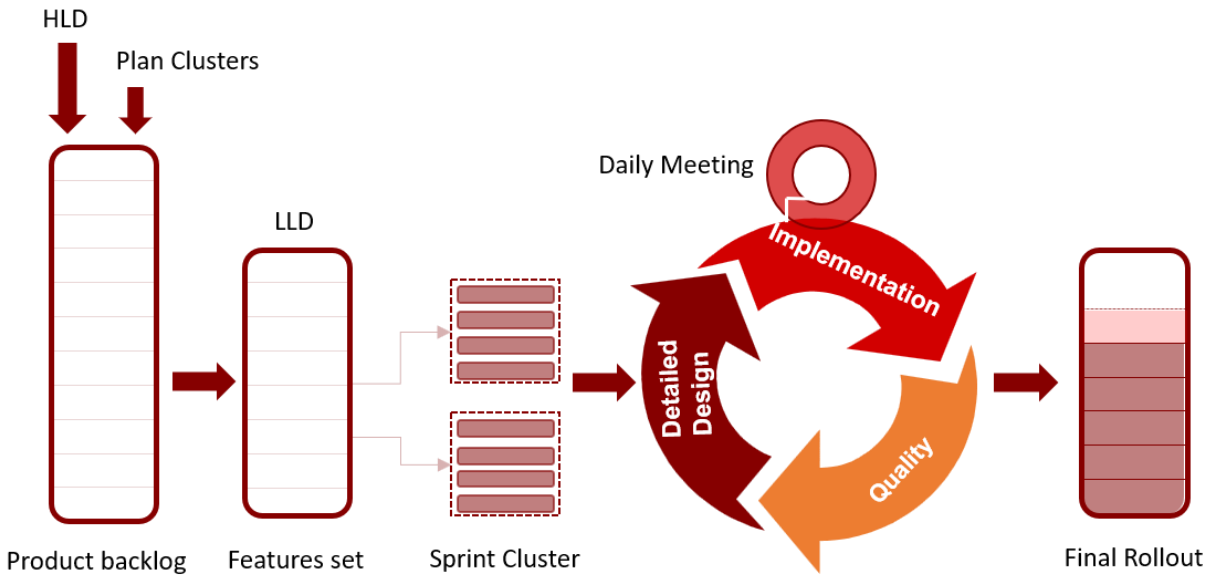


Figure 39 - Application of an Agile Methodology to the Telecom Industry

To facilitate the transition, the first stage is to prepare the company to the change by mapping the old way of working, which is the reason why Chapter 3.3 was developed, allowing a full understanding of the current process to underline the steps that should remain unchanged. Then it is important to understand the employees that make the team up to grasp how they would react to a change and which countermeasures should be taken; at the same time, the right agile methodology

has to be chosen and then adapted to the organization and its employees. In this case, the approach that fits the type of projects is the Scrum, as it involves less complexity in the process and as it mainly influences the implementation phase. Lastly, the transformation should first be applied to pilot projects that have a smaller impact over the results of the company to then, in case of positive results, rollout the methodology to the rest of the company. The pilot project is in fact used to create confidence in the rest of the employees over the benefits of an agile methodology and gain knowledge on how to mitigate the negative impact of the transformation (***Figure 40***).

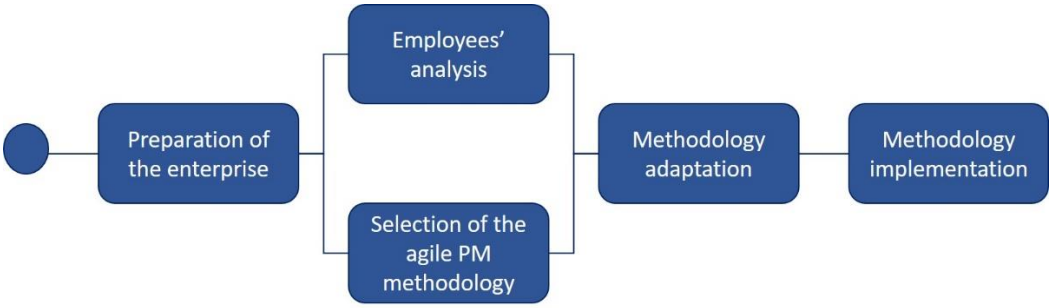


Figure 40 - Transformation Process

As mentioned, in the transformation process carried in the case analyzed, the introduction of the agile methodology does not impact the stages of the process, but the way the interaction is carried out. In this matter two points become extremely important, both related to strong communication, emphasizing the importance of reaching all the stakeholders of the project:

- Team-work and meetings,
- Collaboration with the client.

Team-work involves regularly meeting to discuss about the progress of the project. In fact, at each iteration, the team members should discuss the adequacy of the work assessment and of the methods and techniques used. Too often the plan is decided only by higher managers together with the client without taking into consideration the feasibility of the solution for the rest of the team. The consequence is that the project team is constantly pushed to achieve results that are often not feasible, bringing frustration into the project environment. At the same time, the meeting is a way to openly discuss about the mistakes that were made and to look for improvements by learning from others.

When talking about meetings it is important that the amount of information is flowing at the right level as overloads would make it hard to highlight the important factors; for this reason different meetings have a different occurrence rate based on the purpose and scope aimed to achieve. A meeting is in fact necessary if an outside input is required and real-time conversation is needed to update more people at the same time or to stimulate the debate.

In the context three types of meetings should be introduced:

- Daily stand up meetings both in the central office and in the regions to update the whole team about the progress of the previous day and the expectations for the current day, highlighting the problems that were encountered. Too often the exchange of information is slow, decreasing the efficiency in the problem solving, as problems are known by the

whole team when it is too late to solve them. Through a daily meeting the whole project team can be updated about the current status of the project, going from the delivery of the material, to the rollout phases, to the quality checks. In this way the information that is used is always up to date. This is also an important point that pushes in the direction of a common platform, which will be presented in the following chapters.

- Sprint planning meeting twice per month to update the rollout plan. Currently the project team organizes monthly meetings to determine the schedule and number of sites that will be built in the following month; however, an internal meeting is not organized before the gathering with the customer, and to update the figures based on the progress. Which means that often agreements are taken without taking into consideration the requests and issues coming from the rest of the team. Introducing an internal meeting would facilitate the negotiation with the customer of terms that are more feasible and realistic, without ending up not being able to maintain the expectations.
- Sprint review meeting once per month to analyze the results of the sprint and review the mistakes that were made either in the forecasting or in the way the work was carried. Without a review meeting, each month the same mistakes are done and the project team never grows.

Several surveys and researches showed how the autonomy of the team has a positive effect on the efficiency of the project as reducing the bureaucracy through less documentation gives less boundaries to the project team; however, information still needs to be shared and doing it face-to-face is often more effective than sharing emails (that often do not get to the people that really need them), especially in a context where change is a key factor and it influences all the stages of the value creation.

Apart from the internal view, the main advantage of an agile methodology is the involvement of the client throughout the project life-cycle. At the moment, even though the relationship with the customer is strong and characterized by frequent meetings, the client makes decisions only when they affect its expected position, which brings the meetings to be quite restricted. However, in order to have a successful interaction, it is important that the customer has more responsibilities through a more open relationship that pushes in the direction of a more open discussion, as too often the Vendor agrees on conditions that are unrealistic and that are pushed by the customer only because he is not informed about the current real status of the project. With the customer understanding that there are factors out of its position that also impact his results, more realistic deadlines could be met, problems could be more easily solved and a win-win situation would be created.

The importance of the transition in an Agile direction is that it supports a more efficient issue and change management. This has however to be supported by a defined procedure in which all the team members are engaged on sustaining the project manager with analysis and tracking of the impact of the change. In fact, not controlling the status of a change creates confusion on the team members that are never well informed, reducing their commitment. The procedure, summarized in ***Figure 41***, is made of two main phases: preliminary evaluation of the modification, and identification of the type of change, based on its impact. In fact, firstly the change is evaluated to see if all the information required for the check by the PM or Change control board are provided; in this way, the PM does not waste time on analyzing a change that did not come with the necessary supporting data. Then, depending on the impact of the change, the handling of the change management is supported by different business areas: if the change does not modify the contract

and does not overpass the budget limit, the coordination and responsibility is given to the PM; while if the change influences the budget and/or the contract an escalation to other major stakeholders (Contract Manager, Steering Committee, Customer) is required before the PM takes care of it.

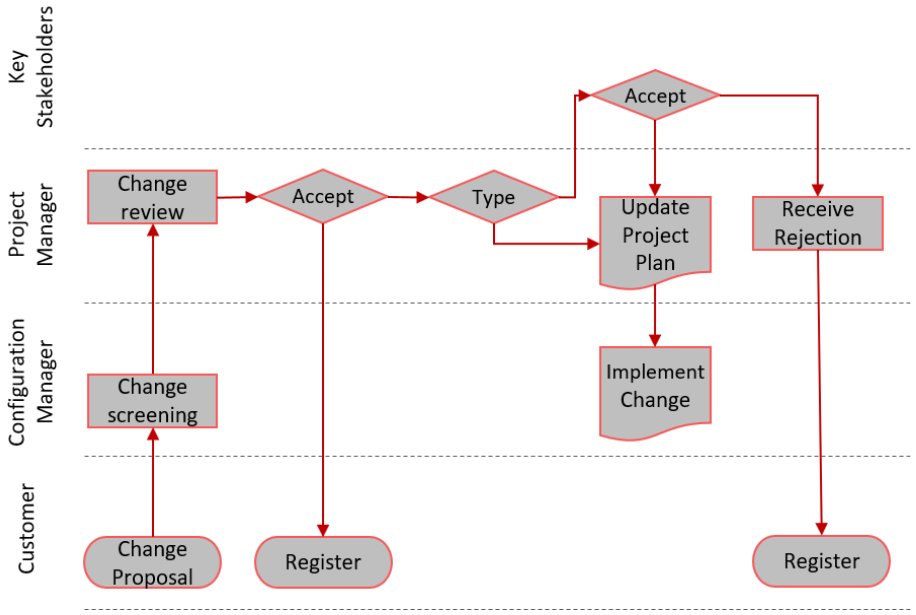


Figure 41 – Internal Change Management Control Process

3.6.3 Closing it right

Closing it right is about correctly defining the point in which the ownership is transferred to the customer, as analysis show how field maintenance projects are the ones that bring worst results to the company. This is achieved by establishing a timeframe where quality checks can be done by the customer, introducing a new process for quality check to accelerate the closure of a site and the acceptance from the customer. In fact, as analyzed in Chapter 3.1, the acceptance of the site is currently a long process that delays the closure of the site. The reason behind these delays is that the quality check is done to all the sites through a site visit of the customer together with the partner. However, as mentioned, partner resources are low and the team normally prefers to use them to proceed with the normal rollout (which brings to 80% of the price paid) rather than "wasting" time on an activity that would bring only 20% of the final value.

Moreover, quality acceptance is given when not only the site is properly functioning, but also all the documentation is correctly provided. If mistakes are found, the site is not accepted and the partner has to work on fixing the problem, to then organize a new site visit with the customer. As it can be seen, the process is quite slow and the customer often takes advantage of minor mistakes to delay the acceptance, and the payment, due to the fact that during all of this time the site is in any case "on air" and the customer can already make money out of it. At the same time, since the Vendor has a lack of visibility in the quality of the implementation, the dispute with the customer can require a long time.

To solve this problem the solution that is proposed is to introduce a methodology and a tool that would reduce the number of sites that would have to be checked, by realizing an online quality approval, which automatically generates a report. The idea is to record through a mobile all the operations that are done on site, based on a checklist provided by the technical director, one for each business scenario, enabling the quality team to remotely check the progress of the site, ***Figure 42.*** If the quality team approves the operations done, the partner can leave the site, otherwise, if possible, the issues are solved on real time without waiting for them to appear at the acceptance stage. The advantage of the remote control is that the partners can receive a real-time support without requiring more resources to go on site and at the same time the amount of manual documentation required is brought to zero, reducing the mistakes that can be made and the workload required to fill them up.

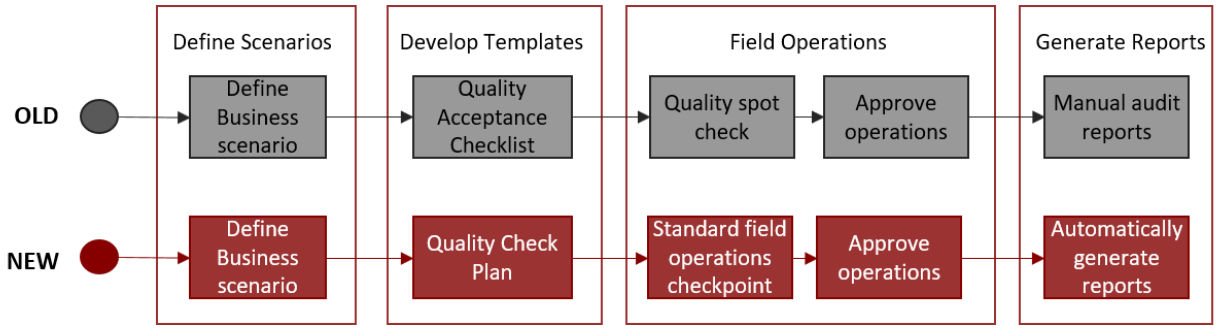


Figure 42 - Old vs. New Quality Check procedure

Of course, in the first stages the customer would never agree on using a tool provided and checked by the Vendor's team as a quality assurance document, and therefore the joint on site quality check would still be required. However, if for the first trial sites in a time period of 2-3 months the quality tool proved to be accurate, an agreement could be reached with the customer to reduce the quality check on site from 100% of the site to 20-30%, and push in the direction of a joint video acceptance that would accelerate the acceptance process, reducing at the same time the costs.

4.5 Improving Risk Management

Many times through the paper it was mentioned the harsh behind the planning of the network rollout as the environment is characterized by a high level of uncertainty, with difficulties in forecasting and therefore limited preparation for action in case a problem is encountered. In this context, managing risks can be very complicated, reason why in the construction industry a widely accepted and specialized risk management method does not exist yet and companies still work with approaches based on static values and single parameters that do not fit the changing environment.

Risk management approaches are not fully accepted and understood by the team members and by the PMO, which leads to a poor handling of the risks and a shallow analysis. In fact, the input and data necessary to estimate the impact and probability of occurrence are difficult to obtain, and the outcomes that are produced during the monitoring phase are often hard to understand and interpret, which leads the teams to underestimate the importance of this procedure and to simplify the process by using static estimations. Moreover, while in the early phases the team is still willing

to invest time on risk management, the more the project evolves, the more the resources become more busy and therefore neglect the risk monitoring phase, which leads to big problems when the risks actually happen.

With the implementation phase going in the direction of an agile approach through a dynamic planning, already implemented, and a flexible management led by an stronger focus in the team-work and communication management, presented in the previous paragraphs, it becomes necessary to manage also risks with a flexible approach ensuring that changes are taken into account and that the information used is always up to date. This is accomplished by simplifying the process, ***Figure 43***, reducing the number of phases, by introducing tools that support the decision process, and by assigning owners responsible of the monitoring of the risk in order to increase the sense of responsibility and importance of performing this activity.

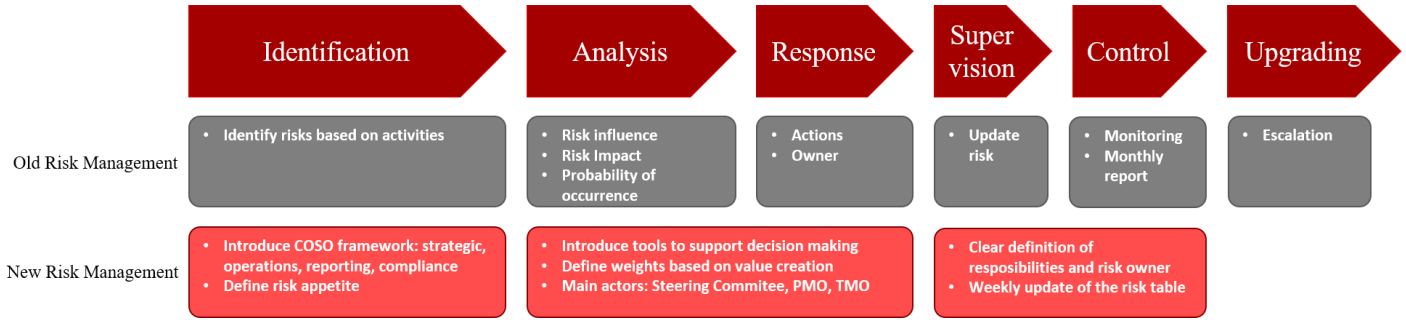


Figure 43 - Risk Management scheme old vs. new

Introducing the idea of agility also in the risk management starts by considering all the aspects that can affect the project. In fact, in the analysis carried it was noted how the Vendor very often focuses on risks that can impact the project goals of time, cost, and quality parameters without considering that in order to have a successful project the liquidity has to be maintained and therefore all the factors that can influence the financial performance of the project should be considered. The idea is that every entity that exist in a project has to provide or help provide value for the stakeholders; if an activity is not necessary for the goal then it should be removed from the process. The role of the management is to determine how much uncertainty each activity has and try to develop a strategy that pushes in the direction of enhancing the chances of the activities associated to opportunities and reduce the ones related to negative risks. Due to the high level of uncertainties in the telecom construction industry, the goal is thus to be able to develop a flexible risk management methodology that aims at achieving a balance between the profits and growth of the company and the chances of negative risks happening. This is achieved by following some concepts:

- Having a proactive approach enhancing the risk response capabilities and pushing in the direction of seizing opportunities;
- Monitor the environment and the progress of the project using a large amount of data to reduce the chances of surprises that can lead to losses;
- Manage the scenario generation including cross-department risks;
- Improve the learning capabilities in order not to repeat mistakes,

- Develop a strategy that applies flexibility to the whole process.

Having this in mind, the idea is to apply to the case analyzed the COSO framework[8] adapting it to fit the risk-control matrix of the Vendor in order to reduce the audits required. The idea of the COSO framework is to divide the risks into four main categories: *strategic*, which are related to high level goals, *operations*, which influence the daily work and the way the resources are distributed and impact the assets and finance, *reporting*, which looks at the reliability of the information provided for decision making, and *compliance*, which are related to the delivery of an output that follows the laws and regulations. Of these, not all are internally controllable, as some are related to external events. However, mapping also external risks is important both to give a complete oversight to the management of the factors that could influence the output of the project, and to ask for collaborations of third parties that could help in managing the external risks.

For each of these four risk categories, seven activities can be carried to properly handle the risks. These can be represented as a risk management plan that provides, through a series of procedures, tools, documentation and techniques, the sequence of activities that has to be carried, to face the risks. At the end of the project, a risk register, ***Table 6***, should be provided as documentation for future projects; including all the documentation collected throughout the project for each risk in terms of qualitative and quantitative analysis, risk response, and impact during the monitoring phase.

Table 6 - Risk Register Template

<table>
<tr><th>Identify Risk</th><th colspan="2">Qualitative analysis</th><th>Quantitative analysis</th><th colspan="2">Risk Response</th><th>Risk Monitoring</th></tr>
<tr><td>ID</td><td colspan="2">Probability</td><td>EMV</td><td colspan="2">Risk result</td><td>Status</td></tr>
<tr><td>Description</td><td rowspan="3">Impact</td><td>Cost</td><td>Risk decision tree</td><td colspan="2">Risk owner</td><td>Risk audit</td></tr>
<tr><td>Classification</td><td>Scope</td><td></td><td>Action</td><td>Preventive</td><td>Learned Lessons</td></tr>
<tr><td>Frequency</td><td>Quality</td><td></td><td></td><td>Contingency</td><td></td></tr>
<tr><td></td><td colspan="2">Matrix P*I</td><td></td><td></td><td>Corrective</td><td></td></tr>
<tr><td></td><td colspan="2">Priority rate</td><td></td><td>Response</td><td>Avoid</td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td><td>Mitigate</td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td><td>Transfer</td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td></td><td>Accept</td><td></td></tr>
<tr><td></td><td colspan="2"></td><td></td><td colspan="2">Risk response plan</td><td></td></tr>
</table>

[8] COSO, Committee of Sponsoring Organizations, is a Treadway commission that developed in 2001 a framework to help businesses assess and enhance their internal control systems providing key principles and concepts, and clear direction and guidance to effectively identify, assess and manage risks.

4.5.1 Analysis of the internal environment

The first step into risk management should be to perform an analysis of the internal environment to understand how the risks are viewed and addressed in the company. In fact, risk management starts from a clear understanding of it by the top management, who has to provide a framework that matches the business goals, providing managers a consistent document on how to respond to risks.

The output of the analysis performed is a value that is known as *risk appetite*, which is defined by the ISO 31000 [9]as "the amount and type of risk that an organization is prepared to seek, accept or tolerate". The risk appetite defines thus the amount of risks that the board and top management evaluate as acceptable as the company has enough resources (financial, human, and intangible) to react to it, and as they are considered as bearable in order to achieve the strategic objectives.

This evaluation aims at producing a document that defines the limits to each of the major risks, which when breached require remedial actions, the documentation required for the escalation procedure, to simplify the resolution process and to provide transparency in the critical decisions procedure, and the roles and responsibilities in the monitoring and escalation phases, in order to ensure that in case of occurrence the company is ready to react to the risk.

Bearing in mind that everybody is responsible of risks, as all the team members should be required to provide ideas for strengthening risk management, three figures are of particular importance: the top steering committee, who should provide an oversight about the risks of the project ensuring that the major risks are taken into consideration; the PMO and TMO leaders, who provide the initial assessment of the available capabilities for a more deep evaluation.

The reason why all the team has to be involved when talking about risks is that, in case of critical situations, everyone will be aware of the responsible person and the communication internal to the team will be more effective. In fact, to have a successful risk management it is important that knowledge and experiences of past situations are shared inside the team to train all the team members on recognizing problems and how to manage them.

4.5.2 Risk Identification

Risk identification aims at establishing which are the internal and external events that could affect the achievement of the objective, dividing them into risks and opportunities. In order to identify the highest number of events it is very important that the strategic direction of the project is understood by all the team members, on this matter, the steering committee has a high importance as it has to provide the most information possible to solve the concerns of the other team members, ensuring that almost all the problems that can be faced are discovered in the early stages.

Once the strategy is clear, to identify the risks and their consequences on the project a decision tree analysis should be implemented. The reason why this tool is seen as the most appropriate for

[9] ISO 31000 is a standard that provides the principles, framework and a process for managing risks. It is not an official certification, but it can be used as a guideline for internal or external audits.

the type of projects analyzed is firstly that it is a cause-effect method that works in a forward basis, which makes it more simple for every member of the team to help in identifying the possible scenarios and deviations, secondly because it helps finding secondary risks, which with other methodologies would be left out. In this stage, all the team members have to introduce the risks that they could encounter in their daily job and that could affect the performance of the project, impacting negatively the constraints of the Iron Triangle.

To help in the identification process, policies and risks identified in old projects are used as database; in fact, the implementation projects in the industry tend to be very similar, this is due to the fact that while there are clusters of sites that are different between each other, overall the projects tend to face the same types of clusters.

The difficulty in this phase is that, especially in the first pilot projects, the identification of the risks can be very time consuming as it is not always easy to have the collaboration of all the team members that are involved in other tasks that they perceive as more important.

4.5.3 Risk Assessment and Response

Risk assessment has to be carried to identify the likelihood and the impact of an event over a project, this is a constant activity that should be performed not only in the planning phase but throughout the whole life-cycle to assess if there are new risks and to verify the residual of the ones that are already taken into consideration. A risk should in fact be assessed as:

$$Residual\ risk = Inherent\ risk * \ control\ effectiveness$$

Currently, risks are only associated to a subjective impact and deep analysis are not carried, especially due to the fact that functions are so independent and not controllable by the PMO that they do not spend time on communicating between each other to understand how one function could impact another. However, in order for risk management to be effective, each risk should be connected to a tangible value that can easily show the priority of the risk and the importance of corrective actions. This is especially crucial in the industry analyzed, where the business environment is very dynamic. As mentioned in the literature, the impact of a risk is most of the times not objectively relatable but its value is estimated by experience; for this reason, to manage the collection of the information, risks should be divided based on the process that they impact, being these: business risks, procurements risks, management risks, and technical risks. In this way, questionnaires aiming at collecting the most accurate information can be distributed to the right team to collect their knowledge and attitude towards each risk.

Especially due to the direction in which the model pushes the way of handling projects in the industry, which is project oriented and where project management gains more responsibilities, it becomes important to have tables and values that support the decisions of the PM. In order not to overload the team, the qualitative analysis, which identifies the possible consequences of the risk and its likelihood of occurrence (in subjective terms), should be carried for each risk, while a deeper and more time consuming quantitative analysis should be conducted only for the most important risks with a higher priority in the internal audit matrix.

The output from the qualitative analysis is a matrix, ***Table 7***, that relates the probability of occurrence of a risk and its impact on a percentage scale to facilitate then the numbers' handling, where the impact should be analyzed taking into consideration all the project constraints (time, cost, quality, scope) and giving more weight to the most important ones (time, quality).

*Table 7 - P*I Matrix*

		Impact				
		0.05	0.1	0.2	0.4	0.8
Probability	0.9	0.05	0.09	0.18	0.36	0.72
	0.7	0.04	0.07	0.14	0.28	0.56
	0.5	0.03	0.05	0.10	0.20	0.40
	0.3	0.02	0.03	0.06	0.12	0.24
	0.1	0.01	0.01	0.02	0.04	0.08

The matrix has two positive impacts:

- It allows a visual perception, understandable by all the team members regarding their department or background, of the importance of a risk. Communication is thus facilitated, both within the team and with the stakeholders.
- It groups the risks based on the response that will have to be introduced through the following phase.

For more important and urgent risks, the ones highlighted in red after the qualitative analysis, the risks should be evaluated more deeply, taking into consideration the monetary expenses for each alternative solution and thus deciding if the costs spent will be lower than the increase in the customer satisfaction, and thus in the success of the project, or if the expenses will be higher than the actual return. The idea is to maximize the customer satisfaction, which is one of the most important constraints of the project, minimizing the costs borne.

As an example, it often happens that a site has some quality issues that bring it to not meeting the customer expectations. In this situations, considering that the R&D behind the project is constantly providing updated technologies, the project team has four different options:

- Do minor technical changes, when there is an available time slot, with a cost (pretended) of 8,000 €. In a scale of 1-10, the cost score would be set to 9 and the customer satisfaction level to 6.
- Do minor technical changes, as soon as possible, with a cost of 16,000€ . The cost score would be set to 7 and the customer satisfaction level to 7.
- Do major technical changes, when there is an available time slot, with a cost of 20,000€. The cost score would be set to 6.5 and the customer satisfaction level to 8.
- Do major technical changes, as soon as possible, with a cost of 40,000€. The cost score would be set to 2 and the customer satisfaction level to 10.

To decide the best solution a global score has to be identified, giving before a weight to the most important value. In this case, since the quality is more important than the price, the weight of customer satisfaction would be set to 0.6 and the one of the costs to 0.4. The result would thus be that the optimal solution is the third, ***Table 8***:

Table 8 - Example of evaluation of the alternatives, based on the impact

	Global score
Solution 1	0.6*6 + 0.4*9 = 7.2
Solution 2	0.6*7 + 0.4*7 = 7
Solution 3	0.6*8 + 0.4*6.5 = 7.4
Solution 4	0.6*10 + 0.4*2 = 6.8

Once the company becomes more familiar with the procedure of risk management and its importance, an option would be to introduce an internal audit that would provide advice and consultancy in order to improve the process. This idea could already be considered in the early stages of the risk management transformation, but only if used in an yearly basis to evaluate the output of the process used to highlight the points that could have been handled in a different way. In fact, introducing a more frequent audit with a consultancy role, would impose a change in the company not bearable by the employees that have to gradually adapt to it.

After the risk assessment has been terminated and the project team has an overview of the impact that a risk can have on the project, no matter the priority or impact of the risk, actions have to be taken. The idea is that the project team should focus on minor risks, with each member taking care of the risks where he/she is assigned as owner, escalating the risk response of the most impactful risks to the higher management and Steering Committee who will decide based on the risk appetite and on the portfolio of risks being handled.

The actions that can be taken are the ones described in Chapter 2.4.2.3:

- Accept
- Mitigate
- Transfer
- Avoid

The harsh in the response planning is that there are different risks that impact different points of the project and different functional departments; which leads to discussions on how important is to take an action to mitigate a risk or not. This is another reason why giving a stronger role to the PMO could have a positive impact on the project, as the Project Manager would have a vision more focused on the long term and on the result of the project, rather than the result of the particular function, and thus solve the controversies of the team.

The output of this phase should be a table, ***Table 9***, providing all the relevant information for the monitoring of the risks, which are the definition of the risk, with a description understandable by all the team members, the information collected in the risk assessment, the trigger event that causes the risk to take place, the response plan established, and the owner of the risk.

Table 9 - Risk Monitoring table template

	Risk ID	Risk description	Risk assessment		Risk trigger	Risk Response plan	Risk owner	Risk closure
			Impact	Probability				
Risk 1								
Risk 2								

4.5.4 Risk Monitoring

Once the project is ongoing, too often the project team forgets to include in the monitoring procedure an activity that aims at controlling the status of the risk; which leads to having to deal with problems, when it is too late to positively implement the risk response that was established in the planning phases.

It is therefore important that each risk owner constantly monitors the risk assigned to his/her responsibility, by following the process from beginning to end, collecting and analyzing data and assessing if the risk is:

- Irrelevant, with the trigger event far from the project horizon. In which case the control being carried is evaluated, to make sure that it is still effective for recognizing the risk;
- Controlled, if the risk is still under control, but requires attention as critical situations could happen and the response plan has to be ready;
- Critical, if the risk is inevitable and it is no longer possible to reduce its impact. In this case a backward evaluation is performed to understand which control point failed in identifying the risk, and if other factors could be happening due to the risk taking place.

To correctly define a response plan, the risks identified and assessed are organized into a matrix that establishes the importance of a risk based on the existing control effectiveness. In this way, more effort will be put into identifying a strategic plan for the risks that were not correctly managed in the past. In this matter, while for the past risks the information collected during the project is used as database, for new risks, to understand the effectiveness of the control that is being applied, testing through data analysis are carried to evaluate the impact of a change in one factor to the overall goal.

4.6 Organizational structure change

During the description of the normal scenario, it was already presented how the lightweight matrix that characterizes the organizational structure of the Vendor analyzed is one of the triggers for problems encountered during the project lifecycle. This negative impact becomes more relevant when looking at the changes that are proposed, in the previous chapters, in the way to handle projects, being these the introduction of an Agile approach and of a stronger Risk Management process. The changing and flexible environment that brought to designing new strategies for the process, impacts also the organizational structure, that in order to promote coordination and focus in the project has to be transformed into a more project-oriented version.

A question that comes to mind is: why the Vendor still uses a lightweight matrix if it has a negative impact? The reason behind this choice is that when resources are assigned to functions, and have to fulfill functional KPIs, they feel more secure than when assigned to a project, which is always seen as an entity with a more unstable and uncertain output. At the same time, functional structures push in the direction of high quality and good performance, which are two constraints for the projects. This second point was valid especially in the early stages of the company, when the volume of the business was not so high and experience in quality and efficiency terms were still unknown. However, with the business growth and with the expansion of the portfolio offer, which brings to an increase in the alternative scenarios, efficiency is no longer boosted by the large-scale and the lightweight matrix no longer supports the business as it has a series of contradictions, with a lack of understanding on who is responsible of decisions, which slows the decision-making process, and with coordination problems.

To improve the quality and productivity an organizational change that supports new working practices is required; it is important to bear in mind that an organizational transformation is risky, as challenges from the employees that might not see the advantages of the change may arise, making the process slower and less effective. For this reason, the management has to underline the benefits, strengthening the communication across the organization, and promoting at the same time a support system for the employees to show people how to operate in the new structure. In the case analyzed, literature reviews underline the benefits that the company could gain from a strong-matrix structure, being it more suitable for the objectives of the project, boosting the success criteria that have a higher priority for the project, which are time and change, ***Table 9***.

Table 10 - Impact of Strong and Light matrix over the project constraints

	Strong Matrix	Light Matrix
Time	High	Low
Performance	Low	High
Change	High	Low
Visibility	High	Low
Security	Low	High

To make the matrix work, since there two role figures, being these the PM and functional manager, it is necessary to clearly define the responsibilities and authorities of each to set boundaries in their span of control. Through the following responsibility chart, ***Figure 44***, it is possible to underline the difference of the responsibilities of the PM in the two cases.

Action	PM Light Matrix	PM Strong Matrix
Monitor Orders		C
Monitor Time	I	R
Monitor Progress	R	AR
Customer Relationship	AR	AR
Planning	C	AC
Monitor Costs	A	A
Corrective Actions		R
Moniotr Quality		I
HR Managment		I

Figure 44 - Role of the PM in the light and strong matrix

The impact of the transformation to the strong matrix is thus that the PM has more control over different stages of the project, granting that the phases for which he/she is accountable are clearly defined. Through a strong matrix, ***Figure 46***, the team is in fact arranged around the project as the PM has more authority over the functional resources compared to the line manager. In this way, the KPIs and the success of the project become of critical importance for the team, creating a stronger sense of identity and a goal-oriented team. However, there are several more advantages to this structure, especially concerning the efficiency of the project; in fact, since the PM has more control over the team, he/she is able to lead and handle the resources with more flexibility and agility, making it easier to schedule and organize the project based on its core activities. Of course, a strong-matrix could have also negative effects, which have to be mitigated. These are: the risk of confusion of the roles and responsibilities inside the team, as with employees applying their skills across different functions different types of knowledge and skills have to be integrated, and loyalties internal to each function, which may still arise.

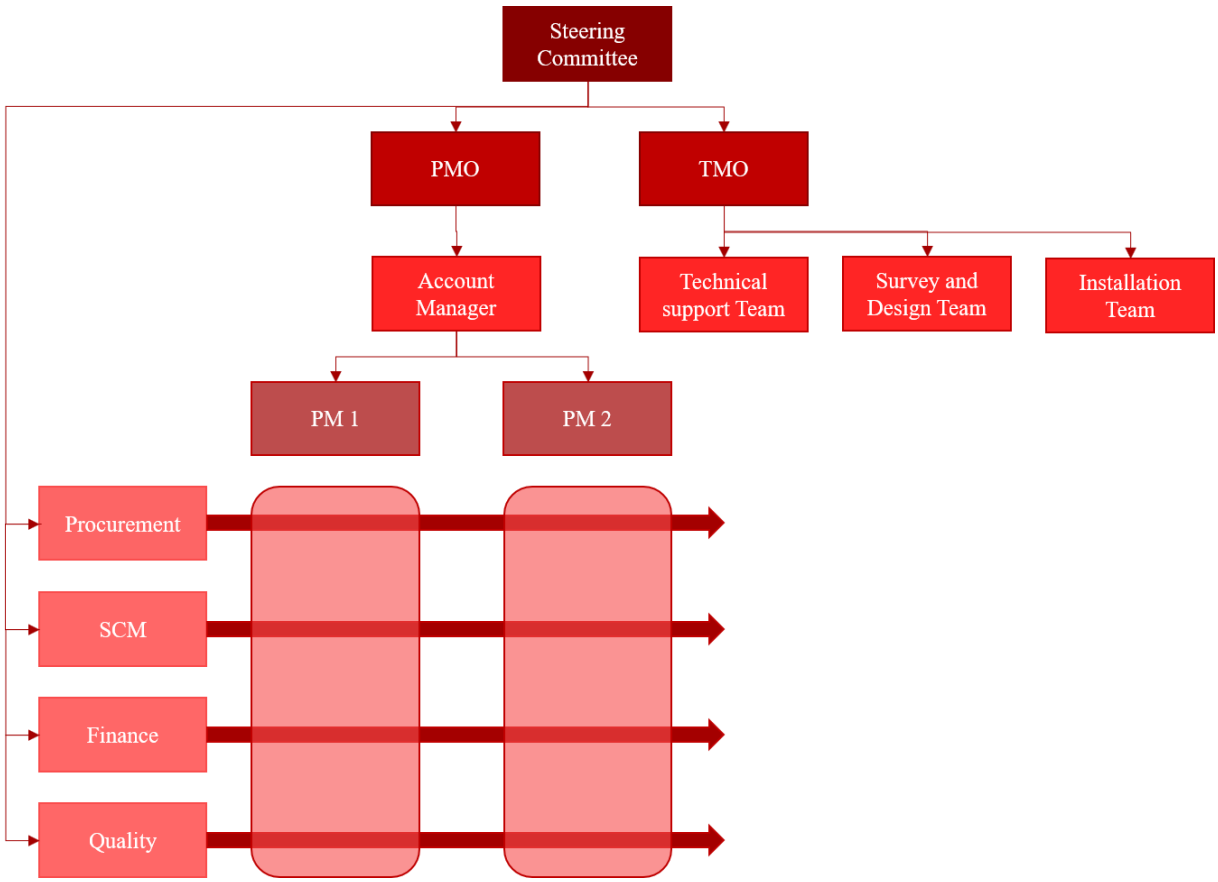


Figure 45 - Organizational chart of the Vendor with a strong matrix

A criteria for success in these projects is how strong is the coordination within the project team and with the customer; factor that is more relevant in the new organizational structure, which emphasizes a smoother and stronger collaboration with the customer. In fact, especially when considering that, with the development of the telecom business, Vendors have more and more to deal with several customers at the same time it is important to understand what kind of coordination is required, how the needs of the team might change over time and how to achieve an effective coordination that satisfies all the parties. In this case, being the customer highly involved since the early stages of the project increases the importance of a coordination model that facilitates the exchange of information and the alignment of the parties, providing a greater customer relationship. This is achieved firstly by providing a structure that shadows the one of the customer, in this case a strong matrix, and then by granting the right communication channels, identifying a figure that can trustfully respond to the requests of the customer being the single point of contact (SPOC) and reducing thus the need to coordinate with different figures, which is achieved by giving a stronger role to the PM. Other than that, two tools have to be correctly used: review meetings (both internally and externally), as presented in Chapter 2.4.1.2, to provide an effective way of information sharing, and, as it will be presented in Chapter 4.7, an integrated tool between the customer and the vendor to allow real-time sharing of the information, reducing the mismatches and misunderstandings.

4.7 Integrated tool

As mentioned several times, the industry is going in the direction of tremendous transformations in terms of technology, which impact the service offered by the Vendor, who has to adapt to the changes by offering more automation and centralization that increase the success rate, efficiency and coordination of the project. This is achieved by operating an internal digital transformation that applies cloud technologies and big data to support scenario-based deliveries through a smart and automated platform.

If we look at the projects in the telecom industry, ***Figure 46***, there is a constant interaction between the Vendor, the Customer and the Partners; however, all parties use different software, and even inside one party, different functional areas do not share applications, due to the fact that very often companies gradually install software based on major needs, which results in business process inefficiencies and integration challenges of the architecture, with data duplicated. Providing a tool that supports ROADS experiences would bring benefits to all parties and increase the chances of success of the implementation of an agile methodology, proposed in Chapter 4.4.2, as agility is boosted by the presence of a common tool that works across teams and departments. Moreover, a standardized but flexible reporting system, would increase the speed and efficiency of the work and of the data analysis, and reduce the costs required for controlling and monitoring, as maintaining different systems and providing constant integration are expensive and time-consuming jobs.

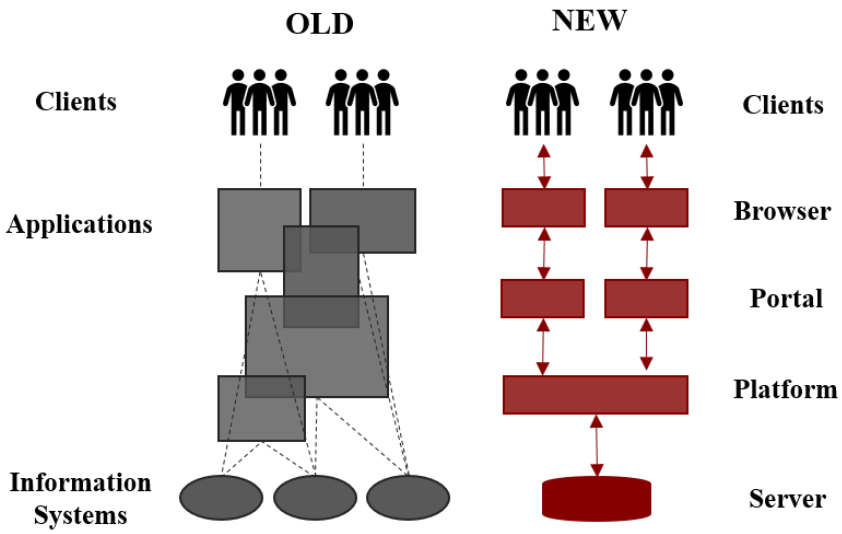


Figure 46 - Comparison of the IS before and after the introduction of a platform

The idea is to provide a platform for project management and rollout operation management that integrates the systems related to supply, procurement, finance, and sales, which still have to deal with the actual transaction, to allow a complete and on-time overview of the project, and to support the integration of planning and operation in order to build cross-area reports and analysis. In this way, multichannel application that provide a low degree of automation are avoided, and process discontinuities are eliminated, assuring that the flow is harmonized and standardized. By

creating an integrated platform, the Vendor is able to increase the efficiency by reusing functions across business units, but allowing at the same time a degree of flexibility thanks to the highest accuracy of the data and thanks to the benefits given by the real-time status.

The platform would be based on three main applications: project management, allowing to manage the projects and the delivery teams, rollout management, to do detail activity flows and activity planning as part of the overall plan, and delivery and information assets, which provide the sites information and the operating data required to deploy the projects. These are then supported by plug and play tools that can be used for planning, designing, doing surveys, and checking quality. Together, these ensure integration, synergy, and constant synchronization, intelligence and automation, and real-time connectivity and visibility by supporting the application through the mobile phone. (***Figure 47***)

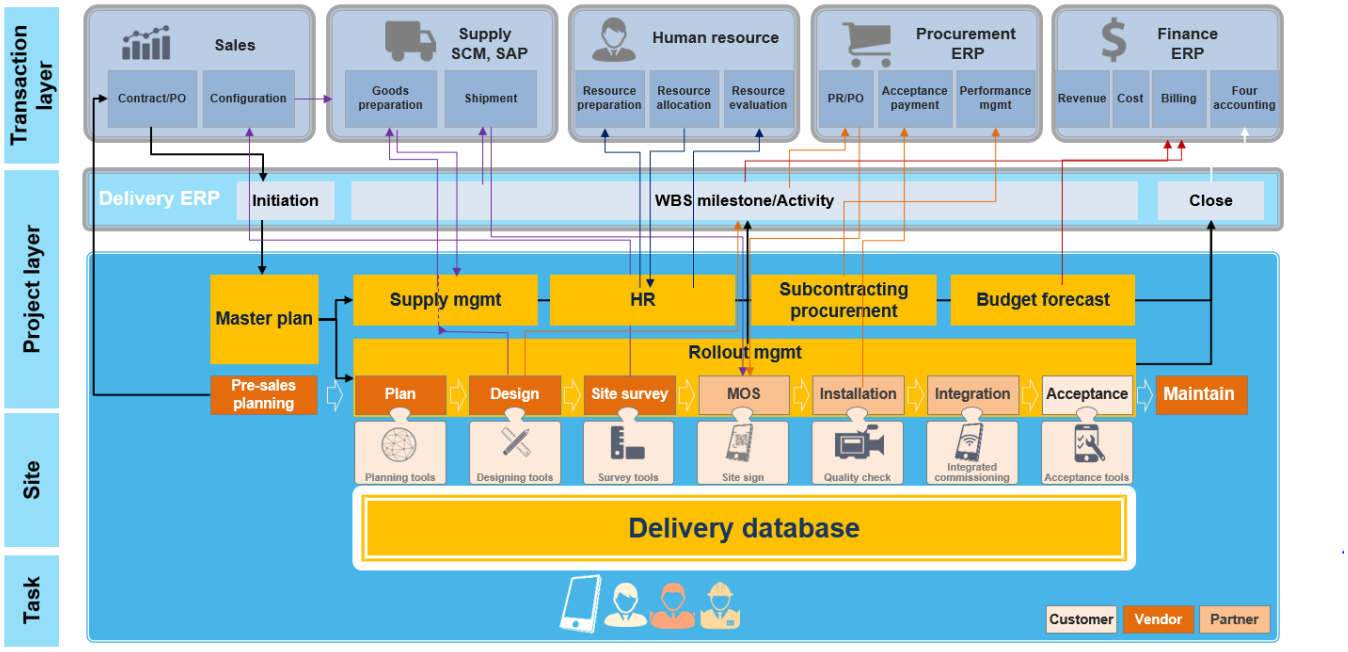


Figure 47 - Mockup of the new IS

The development of and integrated platform would thus bring a series of advantages:

- Reduce the number of internal transactions between layers, increasing the productivity of the resources. Thanks to the availability of joint operations and the sharing of the information sources, the number of internal transactions is brought to zero, as all the resources are able to access the information without needing the support of other functions, reducing the number of mistakes that can be made due to manual work. In fact, the frontline project teams would be responsible for delivering records that are effective, accurate, complete, and up-to-date; while through the platform, the content would be uniformly and transparently distributed in real-time, increasing the agility of the employees.

- Facilitate the monitoring through automatic generation of statistics that evaluate the metrics established, comparing them to the target set by the management, and providing daily data quality checks. This allows to easily track the performance of the accuracy of the Master Plan ($Actual\ sites/Target\ sites$) and of the MOS date ($Deliveries/Planned\ deliveries$), two indicators that evaluate the progression of the project and the accuracy of the forecast provided by the project team.
- Automatic analysis and report generation. Information is automatically analyzed, providing trend predictions, auto assessment, automatic backward analysis to identify deviations and the root cause of problems encountered. Reports and trend analysis have a high importance in the business as, if revisable in real-time, they allow to have more control over the variability of the project. Thanks to the information always being up-to-date, the reports generated are constantly updated without requiring the use of Excel sheets that increase the number of mistakes and that are seen as a bottleneck in the current scenario, as the chances of losing material and information are high.
- Produce visual outputs to support the collaboration between different project teams and functions. Through the collection of large amount of data, the platform can produce visual real-time outputs that simplify the knowledge sharing, and that support the decision-making process by introducing the possibility of a remote support and providing real-time field work monitoring of the progress of the site. The project team is thus be able to monitor and support the site construction in terms of material tracking and technical issues thanks to images, videos, and smart functions inserted in the hardware, which allow to make more accurate and faster decisions.
- Support the relationship with the subcontractors. By increasing the data collection, the accuracy of the planning would be improved, and the visualization of the current status and the sharing of the information would allow to reduce the management complexity, which is a pain point of the subcontractors that do not often have project management capabilities. Moreover, centralizing the issues handling, allows to improve the quality and the efficiency, reducing the risks that come from the subcontractors not undertaking site responsibilities, making quality uncontrollable.
- Increase the customer experience and satisfaction. In a world with fierce competition, providing a high customer experience can be a key success factor, due to the fact that if customers are able to quickly get the information they need, they can both react to issues and participate in improving the process and the output delivery.

In the development of the platform, one activity that has to be taken more into consideration is the integration of the supply chain and logistics function to the whole process. In fact, as it was several times mentioned, a lot of the flexibility of the rollout is taken away by the strictness of the material delivery process and by the low accuracy of the forecast that brings to delays in the construction phase. Through an integrated tool, the relationship between the project and delivery plan has thus to be supported; leading to less over- or under- stocking and keeping the right material available to support a rapid installation. This is achieved by having the site configuration correctly uploaded in the platform, so that the system has under control which material will be required for the sites that are forecasted in the upcoming months. Especially in a context where site shifts are

frequent, the monitoring of the deliveries, if done in a not integrated tool can generate misunderstandings with the technical and financial team that do not have access to the information of the material used to implement a site. Therefore, the operation of the site shift has to be regulated in the integrated platform, ensuring that the request of transfer is automatically visible by all the members of the team. At the same time, a regular backtracking is carried to review the overdue inventory in the subcon warehouse, avoiding that unused material stays in their property.

Introducing a new end-to-end solution with a robust and scalable platform can yes improve the working experience across the organization, but also produce risks of losing data, or interrupting the normal work process, due to data migrations from the applications to the new platform. Therefore, when introducing a new platform, business leaders have to evaluate the requirements and processes used in the current environment, which have a high importance and have thus to be implemented also in the platform, and involve all the key stakeholders when defining the new architecture. Without a high degree of collaboration, the risk is to introduce a large amount of data and functionalities that increase the complexity without bringing any advantage to the service delivery.

When performing an IT transformation, the company could follow different roads, going from the creation of a completely new platform, to the purchase of a solution from a third party, to a migration. Each of the cases has advantages and disadvantages, however, for the purpose of the business and the way projects are handled, the third option is the most suitable. In fact, buying a solution could lead to operational issues due to the fact that the transformation does not come from the inside; at the same time, creating a complete new platform on their own, generates high risks and requires cost and time efforts. The migration is thus a compromise that allows to gradually switch to a new platform, without disrupting the business. To minimize the risks of disruption and maximize the benefits, the literature suggests to follow a three-phase approach:

- Identify the easier changes, reducing the costs by cleaning the old applications, cancelling non-compliant projects, dismissing never used features, and reducing the number of licenses.
- Standardize the technologies and the complexity of the architecture by limiting the customization only to the necessary functions, and by consolidating systems that perform similar tasks.
- Introduce new ways of working to support the key points of the project life-cycle.

The harsh when creating a tool is that, given the complexity of the project and the variety of activities that can take place, it is important to select the relevant information to be shared. At the same time, it has to be defined what the source of the information is, from which party it is provided and from which database it is collected.

5. Conclusion

The telecom industry is entering a phase of big changes, with investments aiming at enhancing the mobile broadband, through the so-called 5G technology, and pushing at the same to a growth of IoT, which brings to an explosion of connected devices and thus of data volumes. This implies that new sites have to be built, both in terms of network expansion to enlarge the coverage, and of type of technology used to support new applications. In this environment, the carriers have to start thinking on how to capture as much value as possible from these investments, bearing in mind that to remain competitive in the market, it is extremely important to be on point with testing and discovering new ways of extracting value; having the advantage that the technology is not always disruptive and in many cases gradual upgrades can be performed, delaying thus the amount of investments required. On the Vendor side, this implies that also gradual upgrades of the technologies have to be provided and that the rollout is implemented with several scenarios in parallel and with frequent change requests coming from the customer based on their financial availability.

A scenario where Vendors try to increase their value by entering in the competition with the carriers is still not contemplated; Vendors are good at making networks, it is hard for them to think about developing in the services world; however, they have to be able to provide hardware that support the transformation of their customers, who perform the services. For the business, it is thus positive that the market is far from saturation, as each generation of technology opens new opportunities for expansion. However, it implies that Vendors have to learn how to adapt their process and methodologies to the requests of the Customers, keeping the service level and customer satisfaction high. This is the reason why, looking at the future, Vendors should start focusing on three main factors: business process, organizational structure, and tools.

The complexity of the process, the continuous interaction with the customer, and the frequent change requests push in the direction of an organizational transformation from a light-matrix, where employees respond first to their function then to the project, to a strong-matrix that would facilitate the interaction with the customer, introducing with the strong figure of the PM a single point of contact. At the same time, through the new organizational structure, more flexibility would be supported, which combined with the application of an Agile methodology, would increase the response rate to changes. This will be important especially when operators, to build the scale required to offer certain kind of services, will start to collaborate, bringing more complexity on the side of the Vendors, who will have to interact with several customers at the same time, responding to customizations and change requests increases. Only by introducing a stronger support system, with frequent meetings and with a defined backlog of priorities, the Vendors will be able to successfully respond to these flexible requests.

Adapting to the industry and to the requests of the customer is important, however, for the company to survive profits have to be generated. This is achieved by implementing a risk management process that aims at identifying and mitigating as many risks as possible before the beginning of the project, without forgetting to constantly monitor their evolution during the project lifecycle. Too often Vendors have to bear costs for issues that are encountered when there is no longer time to solve them.

Lastly, to support the flexibility requested by the industry, Vendors can no longer have several internal applications, with duplicated data and without an integration neither internally, nor with

the customer. With the growth of the complexity of the projects and of the parties, not having a stable and unique platform has a negative impact on the business. Digital transformations take time and can have risks both in terms of investments and of results; however, in this case introducing a tool with trustable and up-to-date information, that supports new technologies and smart applications could drastically reduce the costs of resources needed, of monitoring and costs generated by delays due to mistakes.

Glossary

AC	Actual Cost
ACWP	Actual Cost x Work Performed
AT	Actual Time
AV	Actual Value
BATNA	Best alternative to negotiated agreement
BC	Budget Cost
BCWP	Budget Cost x Work Performed
BCWS	Budget Cost x Work Scheduled
BOQ	Bill of Quantity
BSC	Base Station Controller
BTS	Base Tansceiver Station
CI	Cost Index
CM	Contract manager
CN	Core network
CPI	Cost Performance Index
CR	Change Request
CV	Cost Variance
CW	Civil Works
DPM	Delivery Project Manager
DQA	Quality director
E2E	End-to-End
EAC	Estimate at Completion
EHS	Environment, Health and Safety
ES	Earned Schedule
EV	Earned Value
EVA	Earned Value Analysis
FAC	Final acceptance certificate
HLD	High-level design
I&C	Installation and commissioning
ITO	Inventory Turnover
KPI	Key Performance Indicator
LLD	Low level Design
LT	Lead Time
MOS	Material on site
O&M	Operations and maintenance
PAC	Preliminary acceptance certificate
PCM	Project Control Manager
PD	Project director
PERT	Program Evaluation and review technique
PFC	Project finance controller

PM	Project Manager
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
PMO	Project Management Office
PMP	Project Management Process
POD	Proof of delivery
PPM	Procurement Project Manager
PV	Planned Value
R&D	Research & Development
RAN	Radio access network
RBS	Risk Breakdown Structure
RFC	Ready for commissioning
RFP	Request for Proposal
RFS	Ready for service
RNC	Radio Network Controller
ROADS	Real-time, On-demand, All-online, Do-it-yourself, Social
RPM	Regional Project Manager
SCM	Supply chain manager
SDP	Service Delivery Process
SE	Site Engineering
SI	Schedule Index
SOW	Scope of Work
SPI	Schedule Performance Index
SPOC	Single point of contact
SV	Scheduled Value
TCO	Total Cost of ownership
TD	Technical Director
TIS	Technology in Service
TMO	Technical management office
WBS	Work Breakdown Structure

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