Abstract: Risk Management, in general, is a process aiming at an efficient balance between realizing opportunities for gains while minimizing vulnerabilities and losses. Risk Management should be an endlessly recurring process consisting of phases which, when properly implemented, enable continuous improvement in decision-making and performance improvement. This paper examines the use of simulation techniques in a quantitative risk evaluation. Simulation techniques allow to deal with stochastic problems with many variables and easily view the impact of these variables on the results obtained from the construction of a comprehensive model capable of representing all the possible evolutions of the project. This approach is applied to a case study in a telecommunications service company, in which typically the project life cycle is lengthy and there are many constraints to final authorization to proceed. Hence the attempt is to influence the internal variables in the project to improve the outcomes. These results will be briefly described by the cumulative distribution functions showing how mark-up can be optimized to improve project performance.

Key-Words: Project Risk Management; Simulation; Telecommunications.

1. Introduction

Risks arise because of uncertainty about the future [1]. Uncertainty arising from a multiplicity of sources (including technical, management and commercial issues, both internal and external to the project). The need to identify a project's uncertainties, estimate their impact, analyze their interactions and control them within a risk management structure has only in recent years been realized. It is also widely recognized and accepted that successful management of uncertainty is intimately associated with project success. It is this realization which has led to the undoubted popularity and profile of risk management, which is seen as offering a structured approach to managing the inevitable uncertainty in projects.

In this paper we will concentrate almost exclusively on the potential negative effects of uncertainty. To manage successfully the uncertainties of a project we cannot stop from considering its characteristics of uniqueness (including those which are repeatable, but which will never be the same: changing times, the environment, the stakeholders, the market, laws, etc.). Also for this reason a project is an element characterized by a high degree of uncertainty and consequent high concentration of risks [2]. The flexibility of representation will be an important criterion for the choice of the method for the assessment of risk of the project [2]. Secondly, projects, as in this case, often take place over a long period of time and require the involvement of a wide range of resources, including people, funding, facilities, materials and intellectual capacity, that can have significant repercussions on future cash flows due to changes in economic conditions, technology developments, changing patterns of demand for products or services, new competition, or other operational needs [1]. Therefore, during the life-cycle of the project, we may be prompted several times to review the values assigned to the magnitude of impacts and the likelihood of occurrence of these impacts. Even this aspect will be taken into account in choosing the method of assessment.

For these reasons a project is exposed to uncertainties, therefore to risks, far greater than those of the repetitive and routine activities of an organization [3]. Therefore essential to maintaining control of interrelated variables such as time, cost and quality, it is required to develop a method by which changes in these variables can be studied, analyzed and modified or influenced to affect project outcomes. One way this can be achieved is by the development of an objective function. Unfortunately, most of the times, we are unable to get an explicit representation of the desired objective function that takes into account all the variations of these variables. The need to build a model that allows representation of such correlations is, in most cases, the only possible solution.

Results in project management are diverse and often perceived as an improvement. From historical evidence it can be clearly seen in most cases that the expected objectives do not deviate little from those actually obtained. Morris and Hough’s preface to their list of databases states that “curiously, despite the enormous attention project
management and analysis have received over the years, the track record of projects is fundamentally poor, particularly for the larger and more difficult ones. Overruns are common. Many projects appear as failures [referenced to a Financial Times article], particularly in public view. Projects are often completed late or over budget, do not perform in the way expected, involve severe strain on participating institutions or are cancelled prior to their completion after the expenditure of considerable sums of money”. In summarizing their data-base, they state that “there are hardly any reports showing under runs” . To have an idea, it has been found that for companies of medium-large dimensions and from diverse market segments, it appeared that only 25% of the projects were successfully completed, while approximately 30% are canceled before completion. The remaining projects (which are, therefore, almost 50% of total), have all, in progress, problems of various kinds, a not inconsiderable part of which can be traced back to risky unforeseen events (but not for this all unpredictable) or at least not properly managed [4].

The purpose of Risk Management is to foster a better business and project results. This is achieved through better decision support for planning and design processes to prevent or avoid risks and to capture and exploit opportunities, better contingency planning for dealing with risks and their impacts, better allocation of resources to risks and alignment of project budgets to risks, and better decisions about the best allocation of risk amongst the parties involved in a project activity, including risk sharing as part of the negotiation of contract terms. Together, these lead to increased certainty and a reduction in overall risk exposure. Of these benefits, improved outcomes from the capture of opportunities and the reduction in risk exposure provide the main justifications for undertaking risk management. At the management level, this increased insight is a critical aspect, leading to better decisions. Risk management also provides a framework that avoids sudden surprises and justifies prudent risk reduction and mitigation measures. Risk management also provides benefits for improved accountability and justification of decisions, providing a robust and consistent process that supports decision-making, aside from promoting effective communication and transparency among stakeholders [1]. Unfortunately risk management, systematic and structured, it's still a process developed in a few organizations, rarely in small ones. In some cases it is limited to the management of insurance-related risk, and sometimes so disconnected to the management of financial risks related to the creditworthiness of customers and / or changes. Often it does little for the prevention of risks, or is done in an uncoordinated manner, and in many cases, just to fulfill a legal obligation, but not as a strategic choice. Applying risk management means to implement a methodology to control significant risks the organization can encounter, linked to different aspects of their business. Methodologies related to this discipline can help organizations be more competitive. Perhaps the most important advantages and more evident that one can obtain from such an approach is that it allows you to implement an effective “management aware” of the organization in accordance with the principle of "decisions based on facts". If this should involve the redesign of a business process, to reduce a hazard or to comply with a new mandatory requirement, this does not always translate into higher costs. In many cases it was noticed that, directly or indirectly, you can maintain or increase the value perceived by customers, and profits or market shares [5].

2. Application of Project Risk Management in Telecommunications Service Companies

Initially, project management was almost exclusively part of the plant engineering world. Only in recent years, new areas, starting with IT and telecommunications, have increasingly applied the techniques of project management for projects of their industry. We are therefore faced with the need to use the broader and expedient methodologies of project management for the management of any project in any sector: IT and telecommunications companies, banks and financial services, business services, manufacturing companies, defense, health, public administration [2].

This paper will address more closely issues of managing projects belonging to the constantly changing telecommunications service sector, paying particular attention to issues of risk management. Indeed, in practice, there is significant care in defining the of scope of the project (70%), management of supplies and suppliers (80%), estimating of asset duration (80%), defining project costs (90%), but often overlooked are aspects such as risk management (10%) and communications (20%), critical to ensure project success [8]. Effective project management cannot live apart from management of its own risks.

In this work, a risk analysis of a turnkey delivery project for the installation of a number of Base Transceiver Stations (BTS) for mobile phones is used as the case study. The term BTS indicates the functional unit formed by all transceivers and devices that allow you to provide radio coverage to a cell. The BTS receives and retransmits the signals of mobile phones, allowing it to function. All operators, according to the different policies, started to cover the capitals and major urban centers and then, more or less, all the smaller towns. It should be noted the sometimes crucial role of Local Authorities in the current law giving broad powers of veto in the installation of new antennas, slowing, in fact, the plans of coverage provided by the operators. Other major issues that operators still have to solve are: the possibility that the antennas are harmful to health and the growing opposition from residents regarding the installation of new antennas, because of possible damage to health. The BTS are placed in the territory in numbers depending on the density of the population being...
served, being mainly concentrated in densely populated urban areas. Depending on the number of users served, the BTS are separated by a few hundred meters in cities up to several kilometers in rural areas. The BTS are spread throughout the country depending on the number of users to deal with the problem of multiple attenuation generally found in urban areas and not to maximize the use of available frequencies. The BTS are typically mounted on towers or poles or other supports, installed on the ground or on poles attached to the roofs of buildings. Raw Land in particular is the so-called site on the ground (typical in rural areas), where the station consists of a pole or a tower with foundations on the ground, supplemented by a container or shelter to house the electronics equipment. Roof Top (typical urban) consists of a pole, support for antennas and satellite dishes, anchored or bracketed to structures bearing on the roof of a building, with the occupation of a closed (indoor BTS) or laid directly on the coverage level of a building (outdoor BTS) for location of equipment technology. This type of site is often found in urban centers. Instead, they say co-located when the antennas are mounted on poles, pylons or towers on which there is already an active radio. If possible, they try to use buildings and existing towers. Obviously it is designed to minimize both the cost of providing coverage and the environmental impact caused.

Companies involved in this type of projects can be either primary companies working on behalf of operators or suppliers of the first (from the phase of acquisition, to design, to installation, to testing) following a formulation / acceptance of offer or participation in invitations to tender. The approach to project risk management adopted in this paper is in line with AS / NZS 4360. It consists of several key stages, with feedback achieved through a process of monitoring and control. This standard is well established, covering everything you need to consider and supporting a large and growing number of users in both the public and private sectors in many countries around the world. The generic approach of this standard does it suitable also to be undertaken by organizations with the highest level of risk management maturity. As mentioned previously, it needs to be enriched with state of the art tools and techniques, making appropriate changes where necessary to deal with the case under consideration.

### 2.1 Project Description

The project under study will be well represented by its Project Breakdown Structure (PBS), reported in Fig. 1. The rollout process of project is composited by seven phases, the same shown in Fig. 1. Later we will divide these into two macro-phases, called: Step 1 and Step 2. The first comprising the phase 1 and 2, the second covering the last five.

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**Figure 1 – Project breakdown structure BTS implementation new site**

This is a representation which classifies activities level by level extending to the degree of detail necessary for planning and controlling the project. The PBS must include all elements which are subject to delivery to the customer as well as the main functional tasks that must be performed by individual functions to conceive, design, build, assemble, test and deliver these items. This PBS has three levels of detail (Level 0: Project, Level 1: Steps, Level 2: Activities). This is an appropriate level of decomposition to perform a thorough risk analysis. The PBS refers to the case of projects of BTS implementation with UMTS technology, particularly of new sites, from the stage called “acquisition of new sites”,...
immediately following to the emission of nominal plan. This plan is issued by mobile operator, when it is not fixed by the competent authorities, in order to improving the own coverage of some areas of territory, by the issuance of a number of SARF\(^1\). The process continues until the stage in which the network integration and acceptance by the Customer is achieved. PBS for implementation of Collocated sites on existing systems can be inferred from previous by simply ignoring of the acquisition stage.

### 2.2 Establish the context

At the beginning of the risk management process it is important to explain the organization and project environment in which the risk assessment taking place; to specify the main objectives and outcomes required; to identify a set of success criteria against which the consequences of identified risks can be measured; and to define a set of key elements for structuring the risk identification and assessment process. All this is done at this stage, which, like all others, is concerned by a turn of continuous review to take into account factors not considered before or that occurred afterwards.

### 2.3 Identification and categories of risks

A large number of technique exist for risk identification, such as brainstorming and workshops, checklists, questionnaires and interviews, Delphi method, S.W.O.T. analysis, and various diagramming approaches (cause-effect diagrams, systems dynamics, influence diagrams, systems dynamics, influence diagrams, etc.).

These include creativity techniques and those which draw on previous experience, and group approaches as well as methods for individual use. There is no single “best method” for risk identification, and an appropriate combination of techniques should be used.

Most of the processes for undertaking projects on study may be considered known and the activities that form part of it may be considered routine. This means that you can use the experience of previous projects as a guide to generate the list of risks, and therefore the use of checklists. Unfortunately, we must bear in mind that the surrounding environment, both in terms of community and in terms of legislation, changes with considerable speed and we must take due account. Therefore, an approach to brainstorming with checklists to stimulate private sessions is appropriate to ensure that emerging issues are considered.

The risks identified, in relation to the processes of creation of new sites. This hierarchical structure representing the risks was suspended at the third level in order to have sufficient level of detail and to avoid unnecessary dispersion for subsequent evaluations. Particularly significant is the category of socio-cultural risks. The presence of dissenting communities or local crime can stop at any time, and often without any justification, the development of the site.

Since we cannot give a precise timing of these phenomena, we have that the economic losses vary with the stage of the rollout process to which they occur. It is convenient to take into account these through a penalty factor for the site, which is equal to an average impact calculated as the ratio between the economic losses recorded on the number of sites under consideration. This number is that of a reference sample from which it was drawn the other useful information for subsequent evaluations.

### 2.4 Qualitative evaluation of the risks of the project

Having identified the particular, more significant units of risk for the specific project, it is necessary to assess their effects. Among the methodologies used to elaborate a qualitative assessment of risks to the project, it is preferred to use the Matrix Context (Table 1). This technique was chosen because it allows not only to understand the level of risk of the project but also to highlight issues on which it is possible, or not, to exercise an appropriate contrasting action.

The values of likelihood and impact, in the table, are identified on the basis of experience and series.

<table>
<thead>
<tr>
<th>TABLE 1 – Context Matrix for acquisition new site</th>
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<tr>
<td><strong>CLASSES of RISK</strong></td>
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\(^1\) SARF: Site Acquisition Requesting Form (areas within which sites should be actually built). For each area of research is needed SARF.
If we indicate by "C", "I" and "D" the three possible areas of intervention of the Project Manager (respectively Control, Influence and Dependence) and by \( r_k \), \( r_k \) and \( r_k \) the generic indicators of risk of the individual critical elements calculated for each area of intervention, where totals, at each area of possible intervention, are calculated by:

\[
C = \sum r_k, \quad I = \sum r_k, \quad D = \sum r_k
\]

which may be used to define the Self Determination Index (SDI). This index is very useful because it expresses, in percentage terms, the portion of the project against which there is a real possibility by the Project Manager and his staff to intervene in practice by putting in place countermeasures to reduce the harmful consequences of the actual occurrence of risky events that have been identified in the previous phase. This index is defined by:

\[
SDI = \frac{\left( C + \frac{I}{2} \right)}{\left( C + I + D \right)} \times 100
\]

The project seems rather hetero-determined, and then there are limited opportunities to garrison it in terms of its riskiness. Moreover, the absence of indexes with high weight, in addition to a total of the votes for \( C \), \( I \) and \( D \) of Table 1 less than 50, provides reassurance about the overall low level of risk of the project. The result is shown with a radar diagram to facilitate an immediate view of the level of risk presented by the project and the classes that contribute most to form it (Figure 2). The area of the resulting polygon is quite low, but you can observe a strong asymmetry in correspondence of the axes: Communal Authority, Landscape Constraint, Acquisition and Social-Cultural factors.

![Radar diagram of Context Matrix](image)

From a qualitative assessment of the risk of the project, which concluded with the calculation of the SDI, we can provide useful indications about the most appropriate
choices to be made and the tactics more convenient to be adopted both in the submission / acceptance of offer both in the initial planning of the project. Since, the value found for the SDI (35%), is quite low, we might consider the following possibilities:

• for the supplier, try to get a contract to "time and materials" (rather than a order turn-key, less risky for business customers);
• provide a contingency plan, adequate to cover the losses generated by the occurrence of risky events planned;
• involve the direction, seeking a sponsorship particularly careful and available, to reduce the part of risk internally generated;
• avail of a project team particularly capable, motivated and united, like to point three in the list;
• find technical and organizational solutions to profile higher than the standards corporate, like to point three in the list;
• devote special attention to relationships with stakeholders (internal and external), for a correct estimate of risk is already in the early stages of project.

2.5 Quantitative evaluation of the risks of the project

To a qualitative analysis, such as that performed previously, you can add an economic analysis by estimating the potential losses arising from the occurrence of risky events. This helps the project manager to understand the effects of uncertainty, communicate realistic project forecasts and deploy resources effectively. You can then compare the losses with the costs of the risk mitigations resulting from the implementation of the corresponding Risk Management Plan (RMP).

To make this assessment, Monte Carlo simulations of a logical model of the rollout process are made. The logical model makes a number of assumptions, and approximations both in structure and in quantity that are well representative of the real developments of the project. We use the Monte Carlo simulation to show the many possible outcomes of the project - and to comprise what is likely to occur. This means that you can have, if not perfect information, a more complete picture possible. You can determine which tasks are most important and then manage them appropriately. While no software package is capable of predicting the future, such an approach can help to choose the best strategy based on available information. The strength of this approach is that it is possible to study the behavior of the “real” project as conditions and assumptions are changed. ARENA combines the simplicity of the high level languages with the flexibility of simulation languages allowing integration with general purpose languages such as VisualBasic or C. All this happens thanks to many basic models made available by the software, that can be combined to create a large number of simulations in various fields. ARENA maintains a high degree of flexibility thanks to its hierarchical structure providing the freedom to decide the degree of complexity of the model to be used in performing the simulations.

2.5.1. Logical model of the project

To perform the quantification of the project risk of failure to achieve a desired value of the mark-up (risk exposure), we need to estimate the economic losses, in addition to defining the probability of occurrence of adverse events associated with the risks identified. To do this, a logical model was

\(^{2}\) SAR: Site Acquisition Report. It prepares a SAR form for each candidate, with all the information needed to evaluate them. The quality of the SAR with respect to technical information and especially with regard to the likelihood of conducting a successful negotiation of the lease is crucial: the candidate identified as the preferred option will be a TSI, which is a significant commitment of resources, time and money. If you cannot conclude the lease contract, you must start from scratch.

TSI: Technical Site Inspection. It aims to determine the configuration radio, transmission, construction and equipment of the site. All information necessary for the production of permits to be requested must be collected in this draw.
constructed capable of representing accurately the evolution of the project starting from the implementation of a number of BTS, to the issuance of a SARF up to the delivery to the Client (Site On-Air). Probability values were taken from the same sample used for the estimation of time, paying special attention to the activities covered in the classes: Acquisition, Local Permits, Archaeological and Environmental bound and Socio-Cultural Factors, or those on which you can not exercise any influence since it is not possible to know the areas of Search (SARF) before they are acquired.

For the interpretation and presentation of the results of simulations, we have chosen the Cumulative Distribution Function of mark-up. The intention is to perform a sensitivity analysis to determine the critical factors in the model. The sensitivity analysis is used to classify the factors of influence in the model according to the impact that they have on the results.

Figure 3 shows the comparative graphs of CDF of the report:

\[
\frac{B_{TOT} - C_{TOT}}{C_{TOT}}
\]

which obviously represents the ratio between profit and total costs, for three types of contract, whereas, from time to time, a different number of SARF assigned. Turn Key at Step 1, or those that are paid only for sites where processes can come to conclusion; Turn Key to Step 2, or those that are paid not only for reaching processes to conclusion but also for obtaining the necessary permits, and only to the rate expended to that point (end of Step 1). Finally, a third suggested type of contract, a time and partial expenses, which allows suppliers to recover the costs incurred in carrying out civil works and installation of equipment, even if, for these, they have found impossible to solve the punch items identified. It has been suggested, by experience, a compensation of 75%, for civil works and installation equipment performed. For each of the identified cases, 100 iterations were performed to achieve results sufficiently representative of the potential paths that may be pursued in practice. From these graphs it is possible to infer the accumulated probability of having economic loss and thus the break-even point.

2.6 Results of simulations and risk treatment

The graphs of Figure 3, show the Cumulative Distribution Function (CDF) vs. mark-up for the various numbers of SARF. In the first place, it can be highlighted how, increasing the number of SARF assigned to a project, remains substantially unchanged the ratio of those who manage to complete the process than those who stop at an earlier stage as it is obvious that it does occur, it is not never known the nature of SARF assigned.

Secondly, the types of contracts considered, in all cases analyzed, generating slight deviations, to emphasize the fact that the mark-up obtained is little influenced by the early stages, which are important to the continuation of the process, but a little added value.

Another interesting aspect is the possibility of gaining break even points for the draw very different depending on the number of research areas assigned. Indeed, it is known as a number between 30 and 40 allows to obtain better economic results, since it is nearly or completely canceled the probability of having economic loss. One has to understand, on the other hand, if the supplier is willing or not and whether or not it can support the volumes in terms of costs resulting from that fact. Otherwise, the company must be aware of exposure to a level of greater overall risk.
3. Conclusions

A first conclusion to which you can reach is that the possibility to have more candidates available to help, to a significant extent, especially the most uncertain, i.e. when they are assigned a few areas of research. Conversely, when they tend to increase this tendency seems to disappear as these benefits are offset by the fact that multiple processes come to completion. Although it is true that for many research areas the probability of loss decreases, it is equally true that the curves show the attenuation, to show a reduction in the probability of having earnings above a certain value, i.e. 20%, often used as a reference.

The significant contrast is in correspondence with a number around 40, then return with increasing size. From the comments can be seen as a number roughly equal to 40 is the best situation to be addressed in terms of meeting the expected results. These trends can also suggest to the management the opportunity to confer outside when it is considered too low probability of achieving the desired objectives. However the project is still highly hetero determined.

References