ANALYTICAL HIERARCHY PROCESS, EARNED VALUE AND OTHER PROJECT MANAGEMENT THEMES

A COMPENDIUM OF TECHNICAL ARTICLES

RICARDO VARGAS

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The Author

Ricardo Viana Vargas is an accredited project, portfolio and risk management specialist. Over the past 20 years, he has been responsible for **80+ major projects** in various countries within the petroleum, energy, infrastructure, telecommunications, information technology and finance industries; covering an investment portfolio of over 20 billion dollars. He is also an entrepreneur in the digital economy, with focus on project management tools using artificial intelligence and machine learning.

He is currently the Executive Director of the **Brightline Initiative™**, a coalition of leading global organizations from business, government and not for profit sectors, including the Boston Consulting Group (BCG), the Project Management Institute (PMI) and the Agile Alliance.

Brightline's mission is to provide a knowledge and networking platform that delivers insights and solutions to successfully bridge the gap between strategy development and strategy implementation.

Ricardo is co-founder and managing partner of PMOtto.ai, a cutting-edge virtual assistant that aims to revolutionize how users manage their project and initiatives and interact with project management software.

From 2012 to 2016, Ricardo was the first Global Director of the Infrastructure and Project Management Group with the United Nations Office for Project Services (UNOPS) in Copenhagen, Denmark.

With a UNOPS portfolio of more than 1.2 billion dollars in projects, his work was primarily focused on improving the design, infrastructure and project management of humanitarian, peace-building and development projects all across the world, including but not limited to, Haiti, Afghanistan, Myanmar, Iraq and South Sudan.

In 2016, shortly after his time at the United Nations, he decided to document the lives of some of the most fascinating people from the Zaatari refugee camp in the Mafraq desert in Jordan. Zaatari is an illustration of the tragedy of war.

Amidst extreme violence, millions of men, women and children flee for an indefinite period. In partnership with Ana Cláudia Streva (NÓS), Ricardo developed the treatment of the film and participated in the recordings of Zaatari: Memories of the Labyrinth, a film directed by Paschoal Samora.

The film was released in Europe and Brazil in 2018 and is a co-production of the German Gebrueder Beetz Filmproduktion in partnership with the Brazilian Grifa Filmes, Nós, Globo Filmes, Globo News and Canal Brasil.

He is the first Latin American to be elected Chairman of the Board for the **Project Management Institute** (**PMI**), the largest project management organization in the world, with close to 2.7 million members and certified professionals in 175 countries.

Ricardo Vargas has written **fifteen books** on the subject of project management, published in Portuguese, English, Spanish, French, Danish and Italian, which have sold over 300,000 copies globally. In 2005, he received the PMI Distinguished Award and in 2011, the PMI IS CoP Professional Development Award for his contributions to the development of project management. He has also received the PMI Professional Development Product of the Year Award for the PMDome® workshop, considered the best project management training solution in the world. In 2013 and 2014, Ricardo received the Most Valuable Professional (MVP) Award by Microsoft for his work with Microsoft Project.

Vargas is a recognized reviewer of the PMI's **PMBOK® Guide**, the most critical reference manual in the world for project management and also chaired its official translation to Brazilian Portuguese.

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Introduction

In 2014 I decided to create a collection of technical articles to share the main ideas and studies I have made on the field and also to keep track of the evolution of some of my work. Now I am releasing the third edition, including 2 new articles I published in 2018 and 2019.

Time flies and just to remember, one of the classical articles was the one about the new approach to the PMBOK® Guide. For many new project managers, the article may be perceived as an old article, but the concepts presented in the article were a major driving force to the changes presented in the third edition of the PMBOK® Guide that now presents the data flow diagram in Chapter 3.

Another topic that I cover in several articles is Earned Value Management, the central topic of my master thesis. I also discuss human resource aspects and Monte Carlo simulation applied to project management.

In few years ago I started studying Qualitative Risk Analysis, Sustainability in project environment and Return over Investment of Project Offices and Analytical Hierarchy Process. One of the most intriguing articles was about Neural Networks. When I presented it in 2015 nobody was even thinking what would happen with Artificial Intelligence and Machine Learning. The process I introduced using Microsoft Excel and the Palisade Neural Tools is today present in most of the cloud based solutions and for sure one of the hot topics for the upcoming future.

The most recent articles cover basically my work at Brightline Initiative in topics related to the implementation of strategy. Written in partnership with Edivandro Conforto, Brightline Initiative Head of Strategic Research, they discuss the key elements to be in place in order to get things done: from the design of strategy up to the delivery of benefits. I hope you enjoy this third edition.

Remember that the online version is completely free and it is available at http://rvarg.as/compendium

For sure I intend to keep this book updated with new articles in the future.

Enjoy your reading.

Ricardo

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RICARDO VARGAS

USING THE ANALYTIC HIERARCHY PROCESS (AHP) TO SELECT AND PRIORITIZE PROJECTS IN A PORTFOLIO

Accepted for publication at

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(Русская конференция Управление проектами)
Moscow – Russia - 2010

Abstract

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The objective of this paper is to present, discuss and apply the principles and techniques of the Analytic Hierarchy Process (AHP) in the prioritization and selection of projects in a portfolio. AHP is one of the main mathematical models currently available to support the decision theory.

When looking into how organizations decide over which projects to execute, we can notice a constant desire to have clear, objective and mathematical criteria (HAAS & MEIXNER, 2005). However, decision making is, in its totality, a cognitive and mental process derived from the most possible adequate selection based on tangible and intangible criteria (SAATY, 2009), which are arbitrarily chosen by those who make the decisions.

This paper also discusses the importance and some possible criteria for prioritizing projects, and by using a fictitious project prioritization example, it demonstrates AHP in a step-by-step manner, where the resulting priorities are shown and the possible inconsistencies are determined.

The Importance of Project Selection and Prioritization

One of the main challenges that organizations face today resides in their ability to choose the most correct and consistent alternatives in such a way that strategic alignment is maintained. Given any specific situation, making the right decisions is probably one of the most difficult challenges for science and technology (TRIANTAPHYLLOU, 2002).

When we consider the ever changing dynamics of the current environment like we have never seen before, making the right choices based on adequate and aligned objectives constitutes a critical factor, even for organizational survival.

Basically the prioritization of projects in a portfolio is nothing more than an ordering scheme based on a benefit cost relationship of each project. Projects with higher benefits, when compared to their costs, will have a higher priority. It's important to observe that a benefit cost relationship does not necessarily mean the use of exclusive financial criteria like the widely known benefit cost ratio, but instead a broader concept of the reaped benefits from executing the project and their related efforts.

Since organizations belong to a complex and varying context, often times even chaotic, the challenge of the aforementioned definition resides exactly in determining what are costs and benefits to any given organization.

POSSIBLE DEFINITIONS FOR LOW COSTS	POSSIBLE DEFINITIONS FOR HIGH BENEFITS
Cheaper	More profitable
Less resource needs	Greater return of investment
Easier to be executed	Increase in the number of customers
Less complex	Increase in competitiveness
Less internal resistance	Improvements for the society
Less bureaucratic	Increase in Market Share
Less risks (threats)	Executives and shareholders happier

When analyzing the above table, one can observe that the different dimensions demonstrate how complex it is to come up with an exact translation for the meaning of low cost and high benefits. That is the reason why a unique criterion or translation is not viable enough to determine which project(s) should or should not be executed. Thus it is necessary to employ a multi-criteria analysis (TRIANTAPHYLLOU, 2002) which allows for decisions while taking into consideration the different dimensions and organizational needs altogether.

PMI's Standard for Portfolio Management (PMI, 2008) says that the scope of a project portfolio must stem from the strategic objectives of the organization. These objectives must be aligned with the business scenario which in turn may be different for each organization. Consequently, there is no perfect model that covers the right criteria to be used for any type of organization when prioritizing and selecting its projects. The criteria to be used by the organization should be based on the values and preferences of its decision makers.

Current Criteria used in the Prioritization of Projects

Although decisions are based on values and preferences of the decision makers, a set of criteria or specific objectives can be used while prioritizing projects and determining the real meaning of an optimal relationship between benefits and costs.

The main criteria groups are:

Financial – A group of criteria with the objective of capturing the financial benefits of projects. They are directly associated with costs, productivity and profit measures. A few examples are:

- **Return on Investment (ROI)** – It is the percentage of the profit margin of the project. It allows comparing the financial return of projects with different investments and profits.
- **Profit (currency)** – The value (in currency) of the financial profit gained by the project. A project may have a smaller ROI but its nominal profit can be bigger.
- **Net Present Value (NPV)** – It is the difference between the project benefits and costs taking into consideration that all incomes and expenses are converted to be realized in the current date. In order to do so, it is necessary to bring all future values to the current date by using a given interest rate. That allows the assessment and comparison between projects which have future incomes and expenses from different time periods.
- **Payback** – It is the number of time in periods necessary to recover all of the original project investments.
- **Financial Benefit / Cost Rate** – It is the ratio between the present value of the benefits and the present value of the costs. The higher the ratio, the more viable is the project under the perspective of benefit/costs.

Strategic – A group of criteria directly associated with the strategic objectives of the organization. The strategic criteria/objectives are determined by methods used to cascade corporate strategy like the Balanced Scorecard. They differ from the financial criteria because strategic criteria are specific for any organization. Organizations with different strategies will certainly have different prioritization criteria. Some examples may be to increase the capacity to compete in inter-

national markets, to use eco-friendly practices, to optimize internal processes, to cut expenses in comparison with benchmarking competitors, to improve the reputation of products and services, etc.

Risks (Threats) – It determines the level of risk tolerance that an organization accepts to execute a project. The threat-based risk assessment criteria can also incorporate the assessment of opportunities (HILSON, 2003). However, often times the assessment of opportunities that a project can yield are already covered and taken care of by the strategic criteria. Another equally possible perspective for this criterion entangles the organizational risk of not undertaking the project.

Urgency – It determines the urgency level of the project. Projects considered to be urgent require immediate decision and action, and so they have a higher priority than projects that are not urgent.

Stakeholder commitment – A group of criteria that aims to assess the level of stakeholder commitment towards the project. The higher the commitment to the project, the higher priority the project receives. Commitment may be assessed in a broad manner where all stakeholders are considered as a unique group, or it can be decomposed into different stakeholder groups, like for example:

- Customer commitment
- Community commitment
- Organizational commitment
- Regulatory bodies
- Project team commitment
- Project manager commitment

Technical Knowledge – It assesses the technical knowledge necessary to execute the project. The more technical knowledge readily available, the easier will it be to execute any given project and, consequently, it will cause the project to use fewer resources. It is important to note that, if it is necessary to establish criteria or objectives related to the learning and growth process, these criteria need to be associated with the organization's strategic criteria, and not with any technical knowledge.

Analytic Hierarchy Process

The multi-criteria programming made through the use of the Analytic Hierarchy Process is a technique for decision making in complex environments where many variables or criteria are considered in the prioritization and selection of alternatives or projects.

AHP was developed in the 70's by Thomas L. Saaty and has been since then extensively studied, being currently used in decision making for complex scenarios, where people work together to make decisions when human perceptions, judgments and consequences have a long term repercussion (BHUSHAN & RAI, 2004).

The application of AHP begins with a problem being decomposed into a hierarchy of criteria so as to be more easily analyzed and compared in an independent manner (Figure 1). After this logical hierarchy is constructed, the decision makers can systematically assess the alternatives by making pair-wise comparisons for each of the chosen criteria. This comparison may use concrete data from the alternatives or human judgments as a way to input subjacent information (SAATY, 2008).

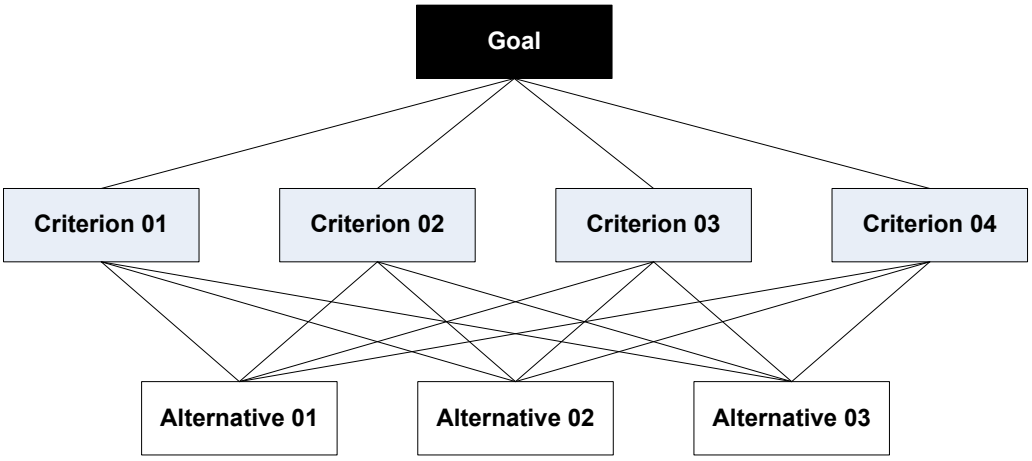

Figure 1 – Example of a hierarchy of criteria/objectives

AHP transforms the comparisons, which are most of the times empirical, into numeric values that are further processed and compared. The weight of each factor allows the assessment of each one of the elements inside the defined hierarchy. This capability of converting empirical data into mathematical models is the main distinctive contribution of the AHP technique when contrasted to other comparing techniques.

After all comparisons have been made, and the relative weights between each one of the criteria to be evaluated have been established, the numerical probability of each alternative is calculated. This probability determines the likelihood that the alternative has to fulfill the expected goal. The higher the probability, the better chances the alternative has to satisfy the final goal of the portfolio.

The mathematical calculation involved in the AHP process may at first seem simple, but when dealing with more complex cases, the analyses and calculations become deeper and more exhaustive.

The Comparison Scale (Saaty scale)

The comparison between two elements using AHP can be done in different ways (TRIANTAPHYLLOU & MANN, 1995). However, the relative importance scale between two alternatives suggested by Saaty (SAATY, 2005) is the most widely used. Attributing values that vary from 1 to 9, the scale determines the relative importance of an alternative when compared to another alternative, as we can see in Table 1.

SCALE	NUMERICAL RATING	RECIPROCAL
Extremely Preferred	**9**	**1/9**
Very strong to extremely	8	1/8
Very strongly preferred	**7**	**1/7**
Strongly to very strongly	6	1/6
Strongly preferred	**5**	**1/5**
Moderately to strongly	4	¼
Moderately preferred	**3**	**1/3**
Equally to moderately	2	½
Equally preferred	**1**	**1**

Table 1 – Saaty's Scale of Relative Importance (SAATY, 2005)

It is common to always use odd numbers from the table to make sure there is a reasonable distinction among the measurement points. The use of even numbers should only be adopted if there is a need for negotiation between the evaluators. When a natural consensus cannot be reached, it raises the need to determine a middle point as the negotiated solution (compromise) (SAATY, 1980).

The comparison matrix is constructed from the Saaty scale (Table 2).

	Criteria 1	**Criteria 2**
Criteria 1	1	Numerical Rating
Criteria 2	1/Numerical Rating (Reciprocal)	1

Table 2 – Comparison Matrix (presuming that Criterion 1 dominates over Criterion 2)

An Example of the Application of AHP in a Portfolio

In order to serve as an example of the AHP calculations for a prioritization of projects, the development of a fictitious decision model for the ACME Organization has been chosen. As the example is further developed, the concepts, terms and approaches to AHP will be discussed and analyzed.

The first step to build the AHP model lies in the determination of the criteria that will be used. As already mentioned, each organization develops and structures

its own set of criteria, which in turn must be aligned to the strategic objectives of the organization.

For our fictitious ACME organization, we will assume that a study has been made together with the Finance, Strategy Planning and Project Management areas on the criteria to be used. The following set of 12 (twelve) criteria has been accepted and grouped into 4 (four) categories, as shown on the hierarchy depicted in Figure 2.

Figure 2 – Hierarchy of Criteria for the fictitious ACME organization

Determining the Comparison Matrix, the Priority Vector (Eigen) and the Inconsistency

After the hierarchy has been established, the criteria must be evaluated in pairs so as to determine the relative importance between them and their relative weight to the global goal.

The evaluation begins by determining the relative weight of the initial criteria groups (Figure 3). Table 3 shows the relative weight data between the criteria that have been determined by ACME's decision makers.

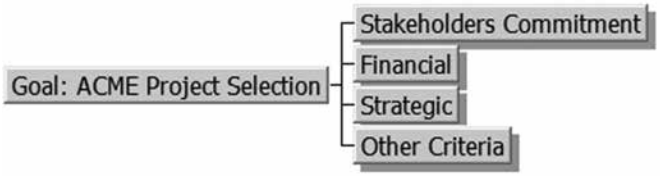

Figure 3 – ACME's initial group of criteria/objectives

	STAKEHOLDERS C	FINANCIAL	STRATEGIC	OTHER CRITERIA
Stakeholders C	1	1/5	1/9	1
Financial	5	1	1	5

Table 3 – Comparison Matrix for ACME's Group of Criteria

	STAKEHOLDERS C	FINANCIAL	STRATEGIC	OTHER CRITERIA
Strategic	9	1	1	5
Other Criteria	1	1/5	1/5	1

Table 3 – Comparison Matrix for ACME's Group of Criteria

In order to interpret and give relative weights to each criterion, it is necessary to normalize the previous comparison matrix. The normalization is made by dividing each table value by the total the total column value (Table 4).

	STAKEHOLDERS C	FINANCIAL	STRATEGIC	OTHER CRITERIA
Stakeholders C	1	1/5	1/9	1
Financial	5	1	1	5
Strategic	9	1	1	5
Other Criteria	1	1/5	1/5	1
Total (Sum)	**16.00**	**2.40**	**2.31**	**12.00**
	Results			
Stakeholders C	1/16 = 0.063	0.083	0.048	0.083
Financial	5/16 = 0,313	0.417	0.433	0.417
Strategic	9/16 = 0.563	0.417	0.433	0.417
Other Criteria	1/16 = 0.063	0.083	0.087	0.083

Table 4 – Comparison Matrix for ACME's Group of Criteria after Normalization

The contribution of each criterion to the organizational goal is determined by calculations made using the priority vector (or Eigenvector). The Eigenvector shows the relative weights between each criterion it is obtained in an approximate manner by calculating the arithmetic average of all criteria, as depicted on Exhibit 10. We can observe that the sum of all values from the vector is always equal to one (1).

The exact calculation of the Eigenvector is determined only on specific cases. This approximation is applied most of the times in order to simplify the calculation process, since the difference between the exact value and the approximate value is less than 10% (KOSTLAN, 1991).

	EIGENVECTOR (CALCULATION)	EIGENVECTOR
Stakeholders C	[0.063+0.083+0.048+0.083]/4 =0.0693	**0.0693 (6,93%)**
Financial	[0.313+0.417+0.433+0.417]/4 =0.3946	**0.3946 (39,46%)**
Strategic	[0.563+0.417+0.433+0.417]/4 =0.4571	**0.4571 (45,71%)**
Other Criteria	[0.063+0.083+0.087+0.083]/4 = 0.0789	**0.0789 (7,89%)**

Table 5 – Eigenvector Calculation (ACME)

For comparison purposes, a mathematical software application has been used to calculate the exact value for the Eigenvector through the use of potential matri-

ces. The results are shown on Table 6.

	APPROXIMATE EIGEN VECTOR	EXACT EIGEN VECTOR	DIFFERENCE (%)
Stakeholders C	0.0693 (6,93%)	0.0684 (6,84%)	**0,0009 (1,32%)**
Financial	0.3946 (39,46%)	0.3927 (39,27%)	**0,0019 (0,48%)**
Strategic	0.4571 (45,71%)	0.4604 (46,04%)	**0,0033 (0,72%)**
Other Criteria	0.0789 (7,89%)	0.0785 (7,85%)	**0,0004 (0,51%)**

Table 6 – Comparative Results for the Calculation of the Eigenvector – Approximate and Exact

It can be observed that the approximate and exact values are very close to each other, so the calculation of the exact vector requires a mathematical effort that can be exempted (KOSTLAN, 1991).

The values found in the Eigenvector have a direct physical meaning in AHP. They determine the participation or weight of that criterion relative to the total result of the goal. For example, in our ACME organization, the strategic criteria have a weight of 46.04% (exact calculation of the Eigenvector) relative to the total goal. A positive evaluation on this factor contributes approximately 7 (seven) times more than a positive evaluation on the Stakeholder Commitment criterion (weight 6.84%).

The next step is to look for any data inconsistencies. The objective is to capture enough information to determine whether the decision makers have been consistent in their choices (TEKNOMO, 2006). For example, if the decision makers affirm that the strategic criteria are more important than the financial criteria and that the financial criteria are more important than the stakeholder commitment criteria, it would be inconsistent to affirm that the stakeholder commitment criteria are more important than the strategic criteria (if A>B and B>C it would be inconsistent to say that A<C).

The inconsistency index is based on Maximum Eigenvalue, which is calculated by summing the product of each element in the Eigenvector (Table 5) by the respective column total of the original comparison matrix (Table 4). Table 7 demonstrates the calculation of Maximum Eigenvalue (λMax)[1] .

[1] The Eigenvector values used from this moment on will be based on the exact values, and not on the approximate values, because the exact values have been calculated and are thus available.

Eigenvector	0.0684	0.3927	0.4604	0.0785
Total (Sum)	16.00	2.40	2.31	12.00
Maximum Eigenvalue (λ_{Max})	[(0.0684 x 16.00)+(0.3927 x 2.40)+(0.4604 x 2.31) + (0.0785 x 12.00)] = 4.04			

Table 7 – Calculation of Maximum Eigenvalue

The calculation of the Consistency Index (SAATY, 2005) is given by the following formula

$$CI = \frac{\lambda_{Max} - n}{n - 1}$$

where CI is the Consistency Index and n is the number of evaluated criteria.

For our ACME organization, the Consistency Index (CI) is

$$CI = \frac{\lambda_{Max} - n}{n - 1} = \frac{4.04 - 4}{4 - 1} = 0.0143$$

In order to verify whether the Consistency Index (CI) is adequate, Saaty (SAATY, 2005) suggests what has been called Consistency Rate (CR), which is determined by the ratio between the Consistency Index and the Random Consistency Index (RI). The matrix will be considered consistent if the resulting ratio is less than 10%.

$$CR = \frac{CI}{RI} < 0.1 \sim 10\%$$

The RI value is fixed and is based on the number of evaluated criteria, as shown on Table 8.

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Table 8 – Table of Random Consistency Indices (RI) (SAATY, 2005)

For our ACME organization, the Consistency Rate for the initial criteria group is

$$CR = \frac{0.0143}{0.9} = 0.0159 = 1{,}59\%$$

Since its value is less than 10%, the matrix can be considered to be consistent. The priority criteria results for the first level can be seen in Figure 4.

Figure 4 – Results of the Comparison Matrix for ACME's Criteria Group, demonstrating the contribution of each criterion to the goal defined for the organization

By looking at Figure 4 and the Eigenvector values, it is evident that the Strategic Criteria have a contribution of 46.04% to the goal, whereas the Stakeholder Commitment criteria contributes with 6.84% to the goal.

Other Calculations Involving the Chosen Criteria

Just like it was done with the initial criteria group for the ACME organization, it is necessary to evaluate the criteria's relative weights for the second level of the hierarchy (Figure 5). This process is executed just like the step to evaluate the first level of the hierarchy (Criteria Group) as it was shown above.

Figure 5 – Hierarchy of criteria for the fictitious ACME organization highlighting the second hierarchy level

The following tables show the comparison matrices for the criteria with the pair-wise comparisons already taken by the decision makers.

	STAKEHOLDERS COMMITMENT CRITERIA		
	TEAM COMMITMENT	ORGANIZATIONAL COMMITMENT	PROJECT MANAGER COMMITMENT
Team Commitment	1	3	1/5
Organizational Commitment	1/3	1	1/9
Project Manager Commitment	5	9	1

Table 9 – Comparison Matrix – **Stakeholder Commitment Criteria**

	FINANCIAL CRITERIA		
	RETURN OF INVESTMENT	PROFIT (US$)	NET PRESENT VALUE
Return of Investment	1	1/5	1/5
Profit (US$)	5	1	1
Net Present Value	5	1	1

Table 10 – Comparison Matrix – **Financial Criteria**

	STRATEGIC CRITERIA		
	COMPETE IN INTERNATIONAL MARKETS	INTERNAL PROCESSES	REPUTATION
Compete in Intern. Markets	1	7	3
Internal Processes	1/7	1	1/5
Reputation	1/3	5	1

Table 11 – Comparison Matrix – **Strategic Criteria**

	OTHER CRITERIA		
	LOWER RISKS FOR THE ORGANIZATION	URGENCY	INTERNAL TECHNICAL KNOWLEDGE
Lower Risks for the Organization	1	5	1/3
Urgency	1/5	1	1/7
Internal Technical Knowledge	3	7	1

Table 12 – Comparison Matrix – **Other Criteria**

The following charts demonstrate the priority results for the sub-criteria for each one of the criteria groups[2] and their respective inconsistency indices. We can observe that none of the criterion demonstrates any inconsistency above tolerable limits.

[2] The data have been simulated and calculated using ExpertChoice 11.5 for Windows, available at *www.expertchoice.com*

Figure 6 – Priority results for the **Stakeholder Commitment Criteria**

Figure 7 – Priority results for the **Financial Criteria**

Figure 8 – Priority results for the **Strategic Criteria**

Figure 9 – Priority results for the **Other Criteria**

The global priority for each criterion is determined by the result of the multiplication of each priority on the first level by its respective priority on the second level. The results are shown on the hierarchy depicted on Figure 10. We can also see that the sum of the weights of all twelve (12) factors is equal to 1.

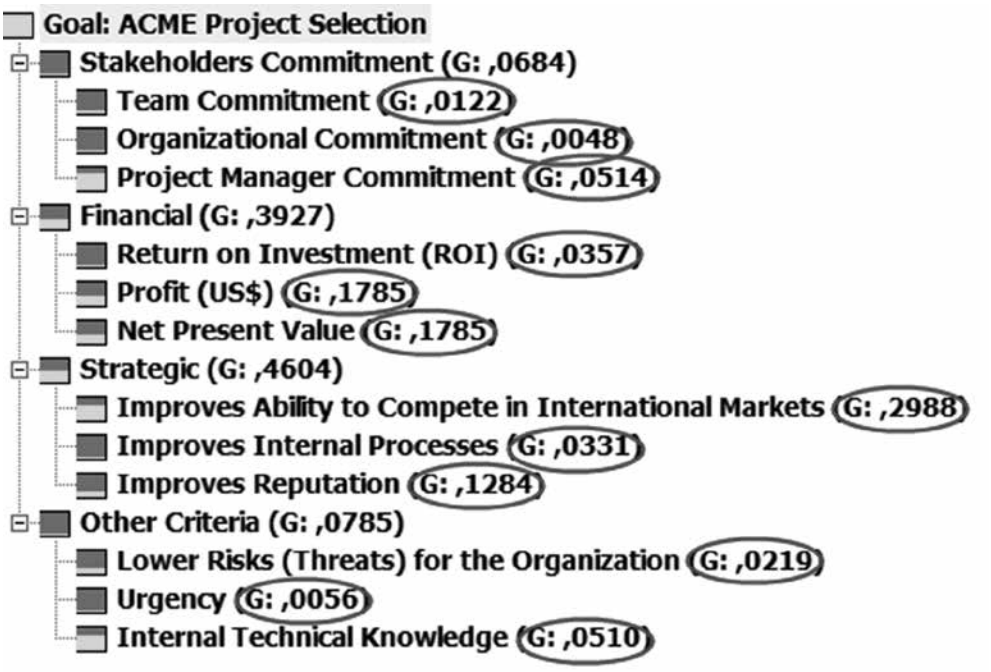

Figure 10 – Hierarchy of criteria for the fictitious ACME organization with global priorities for each criterion

Evaluating Candidate Projects for the Portfolio

After having structured the tree and established the priority criteria, it is now possible to determine how each one of the candidate projects fits the chosen criteria. In the same manner that the criteria prioritization has been made, the candidate projects are pair-wisely compared considering every established criteria.

For our ACME organization, six (6) different projects have been identified and must then be prioritized. The fictitious projects are:

- Move to a new office facility
- New ERP system
- Opening of an office in China
- Development of a new Product aiming at the International Market
- IT infrastructure Outsourcing
- New local Marketing Campaign

In order to apply AHP, the decision makers from ACME organization have compared six projects taking into consideration every one of the twelve established criteria. The results are shown in the following twelve tables.

	TEAM COMMITMENT					
	NEW OFFICE	ERP IMPLEM.	CHINESE OFFICE	INTERN. PRODUCT	IT OUTSOURC.	LOCAL CAMPAIGN
New Office	1	5	3	1/3	9	7
ERP Implementation	1/5	1	1/5	1/7	1	1/3
Chinese Office	1/3	5	1	1/3	7	3
International Product	3	7	3	1	5	5
IT Outsourcing	1/9	1	1/7	1/5	1	1/3
New Local Campaign	1/7	3	1/3	1/5	3	1

Table 13 – Projects Comparison Matrix for the **Team Commitment Criterion**

	ORGANIZATIONAL COMMITMENT					
	NEW OFFICE	ERP IMPLEM.	CHINESE OFFICE	INTERN. PRODUCT	IT OUTSOURC.	LOCAL CAMPAIGN
New Office	1	3	1/9	1/5	5	3
ERP Implementation	1/3	1	1/9	1/7	1	1/3
Chinese Office	9	9	1	3	7	7
International Product	5	7	1/3	1	9	7
IT Outsourcing	1/5	1	1/7	1/9	1	1/3
New Local Campaign	1/3	3	1/7	1/7	3	1

Table 14 – Projects Comparison Matrix for the **Organization Commitment Criterion**

	PROJECT MANAGER COMMITMENT					
	NEW OFFICE	ERP IMPLEM.	CHINESE OFFICE	INTERN. PRODUCT	IT OUTSOURC.	LOCAL CAMPAIGN
New Office	1	7	1/3	1/3	5	3
ERP Implementation	1/7	1	1/9	1/7	3	1/3
Chinese Office	3	9	1	1	7	7
International Product	3	7	1	1	7	9
IT Outsourcing	1/5	1/3	1/7	1/7	1	1/5
New Local Campaign	1/3	3	1/7	1/9	5	1

Table 15 – Projects Comparison Matrix for the **Project Manager Commitment Criterion**

	RETURN ON INVESTMENT					
	NEW OFFICE	ERP IMPLEM.	CHINESE OFFICE	INTERN. PRODUCT	IT OUTSOURC.	LOCAL CAMPAIGN
New Office	1	1/3	1/7	1/9	1/3	1/3
ERP Implementation	3	1	1/9	1/9	1/3	1/3
Chinese Office	7	9	1	1/3	7	5
International Product	9	9	3	1	7	5
IT Outsourcing	3	3	1/7	1/7	1	1/3
New Local Campaign	3	3	1/5	1/5	3	1

Table 16 – Projects Comparison Matrix for the **Return On Investment Criterion**

	PROFIT (US$)					
	NEW OFFICE	ERP IMPLEM.	CHINESE OFFICE	INTERN. PRODUCT	IT OUTSOURC.	LOCAL CAMPAIGN
New Office	1	1	1/7	1/9	1/5	1/3
ERP Implementation	1	1	1/7	1/9	1/3	1/5
Chinese Office	7	7	1	1/3	7	5
International Product	9	9	3	1	9	5
IT Outsourcing	5	3	1/7	1/9	1	1/3
New Local Campaign	3	5	1/5	1/5	3	1

Table 17 – Projects Comparison Matrix for the **Profit (US$) Criterion**

	NET PRESENT VALUE					
	NEW OFFICE	ERP IMPLEM.	CHINESE OFFICE	INTERN. PRODUCT	IT OUTSOURC.	LOCAL CAMPAIGN
New Office	1	1/3	1/5	1/7	1/3	1/3
ERP Implementation	3	1	1/5	1/7	1	1/3
Chinese Office	5	5	1	1/3	5	3
International Product	7	7	3	1	5	7
IT Outsourcing	3	1	1/5	1/5	1	1/3
New Local Campaign	3	3	1/3	1/7	3	1

Table 18 – Projects Comparison Matrix for the **Net Present Value Criterion**

	IMPROVES ABILITY TO COMPETE IN INTERNATIONAL MARKETS					
	NEW OFFICE	ERP IMPLEM.	CHINESE OFFICE	INTERN. PRODUCT	IT OUTSOURC.	LOCAL CAMPAIGN
New Office	1	3	1/9	1/7	5	5
ERP Implementation	1/3	1	1/9	1/9	1/3	3
Chinese Office	9	9	1	1	9	9
International Product	7	9	1	1	9	9
IT Outsourcing	1/5	3	1/9	1/9	1	3
New Local Campaign	1/5	1/3	1/9	1/9	1/3	1

Table 19 – Projects Comparison Matrix for the **Ability to Compete in International Markets Criterion**

	IMPROVES INTERNAL PROCESSES					
	NEW OFFICE	ERP IMPLEM.	CHINESE OFFICE	INTERN. PRODUCT	IT OUTSOURC.	LOCAL CAMPAIGN
New Office	1	1/5	3	5	1	7
ERP Implementation	5	1	7	7	1	7
Chinese Office	1/3	1/7	1	1	1/7	1
International Product	1/5	1/7	1	1	1/7	1/3
IT Outsourcing	1	1	7	7	1	7
New Local Campaign	1/7	1/7	1	3	1/7	1

Table 20 – Projects Comparison Matrix for the **Improves Internal Processes Criterion**

	IMPROVES REPUTATION					
	NEW OFFICE	ERP IMPLEM.	CHINESE OFFICE	INTERN. PRODUCT	IT OUTSOURC.	LOCAL CAMPAIGN
New Office	1	1/3	1/7	1/5	3	1/7
ERP Implementation	3	1	1/9	1/5	5	1/7
Chinese Office	7	9	1	3	7	1
International Product	5	5	1/3	1	7	1/3
IT Outsourcing	1/3	1/5	1/7	1/7	1	1/9
New Local Campaign	7	7	1	3	9	1

Table 21 – Projects Comparison Matrix for the **Improves Reputation Criterion**

	LOWER RISKS (THREATS) FOR THE ORGANIZATION					
	NEW OFFICE	ERP IMPLEM.	CHINESE OFFICE	INTERN. PRODUCT	IT OUTSOURC.	LOCAL CAMPAIGN
New Office	1	5	7	3	5	1
ERP Implementation	1/5	1	5	3	3	1/7
Chinese Office	1/7	1/5	1	1/3	1/3	1/9
International Product	1/3	1/3	3	1	5	1/7
IT Outsourcing	1/5	1/3	3	1/5	1	1/9
New Local Campaign	1	7	9	7	9	1

Table 22 – Projects Comparison Matrix for the **Lower Risks (Threats) for the Organization Criterion**

	URGENCY					
	NEW OFFICE	ERP IMPLEM.	CHINESE OFFICE	INTERN. PRODUCT	IT OUTSOURC.	LOCAL CAMPAIGN
New Office	1	1/3	1/5	1/7	3	1
ERP Implementation	3	1	1/7	1/9	3	3
Chinese Office	5	7	1	1/3	5	7
International Product	7	9	3	1	7	7
IT Outsourcing	1/3	1/3	1/5	1/7	1	1/3
New Local Campaign	1	1/3	1/7	1/7	3	1

Table 23 – Projects Comparison Matrix for the **Urgency Criterion**

	INTERNAL TECHNICAL KNOWLEDGE					
	NEW OFFICE	ERP IMPLEM.	CHINESE OFFICE	INTERN. PRODUCT	IT OUTSOURC.	LOCAL CAMPAIGN
New Office	1	9	9	9	9	3
ERP Implementation	1/9	1	1/3	1/3	1/5	1/9
Chinese Office	1/9	3	1	3	1	1/9
International Product	1/9	3	1/3	1	1/3	1/9
IT Outsourcing	1/9	5	1	3	1	1/9
New Local Campaign	1/3	9	9	9	9	1

Table 24 – Projects Comparison Matrix for the **Internal Technical Knowledge Criterion**

After calculating all priorities and inconsistency indices, it is possible to determine the relative weight of each project for each criterion, as we can see in the following twelve (12) charts (one chart for each criterion).

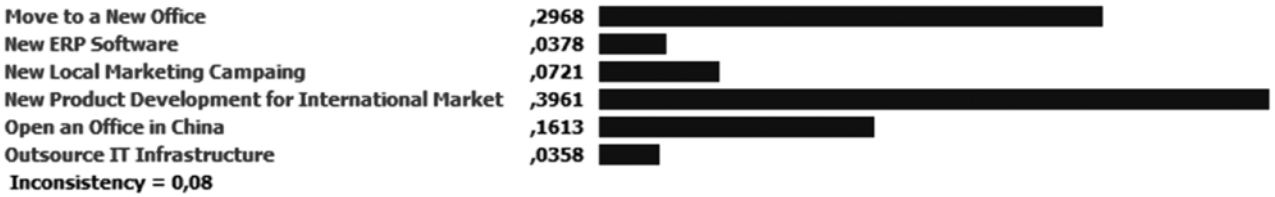

Figure 11 – Priority results for the projects according to the **Team Commitment Criterion**

Figure 12 – Priority results for the projects according to the **Organization Commitment Criterion**

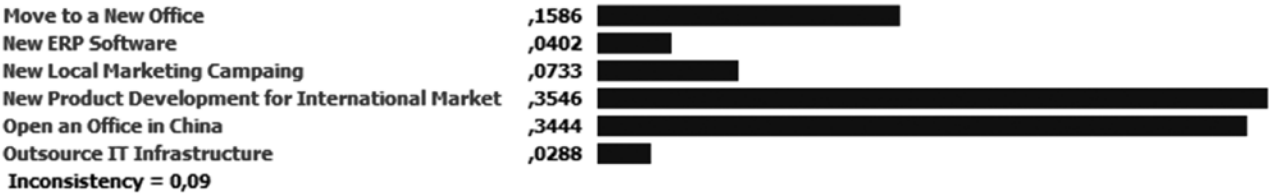

Figure 13 – Priority results for the projects according to the **Project Manager Commitment Criterion**

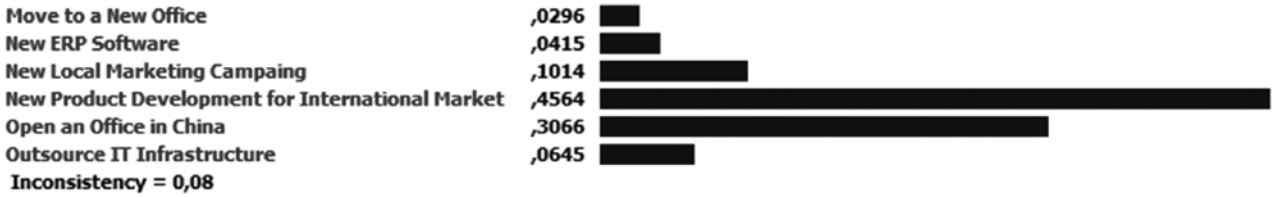

Figure 14 – Priority results for the projects according to the **Return On Investment Criterion**

Figure 15 – Priority results for the projects according to the **Profit (US$) Criterion**

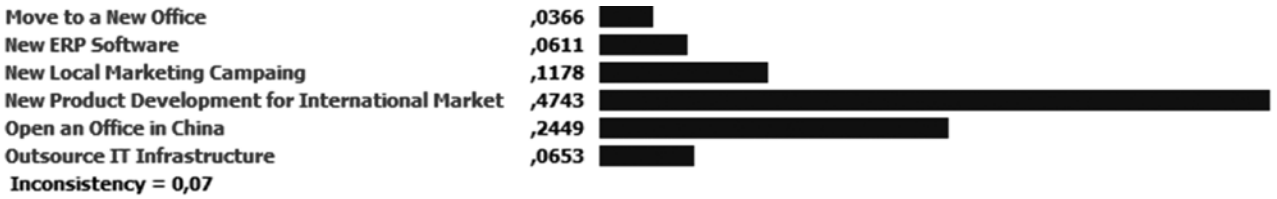

Figure 16 – Priority results for the projects according to the **Net Present Value Criterion**

Figure 17 – Priority results for the projects according to the **Ability to compete in International Markets Criterion**

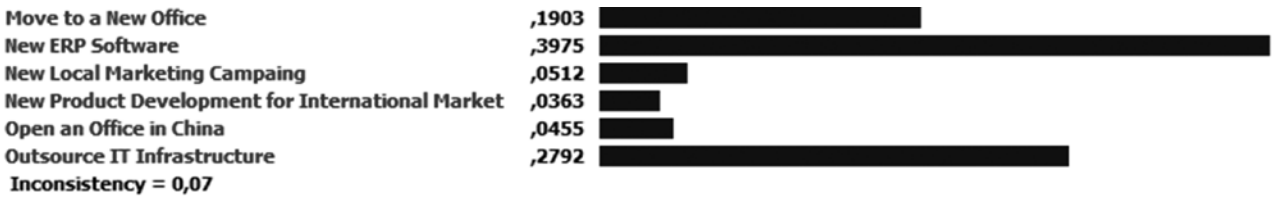

Figure 18 – Priority results for the projects according to the **Improves Internal Processes Criterion**

Figure 19 –Priority results for the projects according to the **Improves Reputation Criterion**

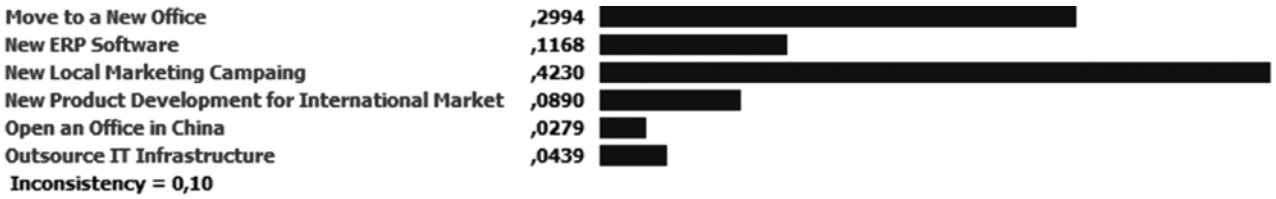

Figure 20 – Priority results for the projects according to the **Lower Organizational Risks (Threats) Criterion**

Figure 21 – Priority results for the projects according to the **Urgency Criterion**

Figure 22 – Priority results for the projects according to the **Internal Technical Knowledge Criterion**

The crossing product of all project evaluations using all criteria determines the final priority for each project in relation to the desired goal.

The mechanism for calculating the final priority is to sum the products of the multiplication of each criterion's priority weight by its alternative weight.

In order to exemplify this process, Table 25 shows the calculation process for the alternative "Move to a New Office"

CRITERIA	PRIORITY WEIGHT	ALTERNATIVE WEIGHT	PRODUCT
Team Commitment	0,0122	0,2968	0,0036
Organizational Commitment	0,0048	0,0993	0,0005
Project Manager Commitment	0,0514	0,1586	0,0082
Return on Investment (ROI)	0,0357	0,0296	0,0011
Profit (US$)	0,1785	0,0315	0,0056
Net Present Value	0,1785	0,0366	0,0065

Table 25 – Final priority evaluation of the Project **Move to a New Office** according to the established and weighted criteria for the ACME Organization

CRITERIA	PRIORITY WEIGHT	ALTERNATIVE WEIGHT	PRODUCT
Improves Ability to Compete in International Markets	0,2988	0,1033	0,0309
Improves Internal Processes	0,0331	0,1903	0,0063
Improves Reputation	0,1284	0,0421	0,0054
Lower Risks (Threats) for the Organization	0,0219	0,2994	0,0066
Urgency	0,0056	0,0553	0,0003
Internal Technical Knowledge	0,0510	0,4796	0,0243
		Results	**0,0992**

Table 25 – Final priority evaluation of the Project **Move to a New Office** according to the established and weighted criteria for the ACME Organization

The same process should be repeated for the other five (5) projects. The final results for all projects are shown in Figure 23.

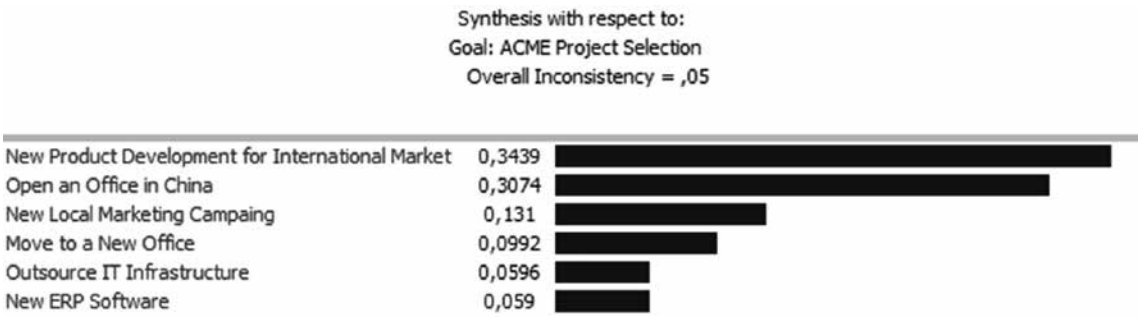

Figure 23 – Final priority results for the for ACME's portfolio of projects

Figure 23 shows that the project with the highest level of adherence to the defined goal is "Development of a New Product for the International Market". It contributes with 34.39% (0.3439). In order to better illustrate the importance of the difference between the weights and priorities of each project, this project contributes with about three (3) times more to the goal than the New Local Marketing Campaign project, which contributes with only 13.1% (0.131) to the global goal.

Conclusion

AHP has been attracting the interest of many researchers mainly due to the mathematical features of the method and the fact that data entry is fairly simple to be produced (TRIANTAPHYLLOU & MANN, 1995). Its simplicity is characterized by the pair-wise comparison of the alternatives according to specific criteria (VARGAS, 1990).

Its application to select projects for the portfolio allows the decision makers to have a specific and mathematical decision support tool. This tool not only sup-

ports and qualifies the decisions, but also enables the decision makers to justify their choices, as well as simulate possible results.

The use of AHP also presumes the utilization of a software application tailored specifically to perform the mathematical calculations. In this paper, the intention has been to show the main calculations performed during the analysis, enabling project managers to have an adequate understanding of the technique, as well as the complexity involved to make the calculations by hand (in case software applications can't be used).

Another important aspect is the quality of the evaluations made by the decision makers (COYLE, 2004). For a decision to be the most adequate possible, it must be consistent and coherent with organizational results. We saw that the coherence of the results can be calculated by the inconsistency index. However, the inconsistency index allows only the evaluation of the consistency and regularity of the opinions from the decision makers, and not whether these opinions are the most adequate for a specific organizational context.

Finally, it is important to emphasize that decision making presumes a broader and more complex understanding of the context than the use of any specific technique. It predicates that a decision about a portfolio is a fruit of negotiation, human aspects and strategic analysis, where methods like AHP favor and guide the execution of the work, but they cannot and must not be used as a universal criteria.

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RICARDO VARGAS

THE INNOVATOR'S MINDSET: RADICAL CAN-DO

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When business leaders are quizzed about what it takes to succeed today, they tend to suggest the usual suspects. Innovation is one constant refrain. But, look around. While radical innovation is a common aspiration, incremental innovation is the more frequent reality. Very few products or services are truly innovative.

Is leadership to blame? Harvard Professor Rakesh Khurana estimates that anywhere from 30 to 40 per cent of the performance of a company is attributable to 'industry effects'; 10 to 20 per cent to cyclical economic changes; and perhaps 10 per cent to the CEO. Our experience suggests this is a maximum figure rather than a mean.

Originality is similarly over-rated. Research by Costas Markides and Paul Geroski of London Business School has highlighted the myth of the importance of being the 'first mover'. Markides and Geroski point out that Amazon was not the first company to focus on online retailing; nor was Charles Schwab the originator of online share dealing. The commercial genius of Amazon and Schwab was to take existing technology and bring it to the mass market. Hardly original—but hugely successful.

So, if it's not leadership or originality, what accounts for innovative success?

The reality is that time and time again, the most innovative organizations are characterized by what we describe as relentless execution driven by a radical 'can-do' attitude and aptitude. They realize that the best strategies in the world will get you nowhere unless you relentlessly make them happen.

Consider how **Henry Ford** revolutionized the auto industry at the turn of the 20th century. More than 17,000 Model Ts were sold during the first year of production. Four years earlier, the world's entire automobile industry produced 22,000 cars. In the 19 years of the Model T's existence, Ford's production total amounted to half the auto output of the world. Along the way, the entrepreneurial crowd that had set out to conquer the new auto market became a select corporate few. In 1914 the Ford Motor Company, with its 13,000 employees, produced 267,720 cars; the other 299 American auto companies with 66,350 workers produced only 286,770 cars combined. Ford had 48 per cent of the American car market, with $100 million in annual sales.

Ford's route to success was not about originality. There were a host of others ahead of him in terms of automotive technology. The fledgling automobile market was highly competitive and crowded. People like Charles Edgar and J. Frank Duryea, Elwood Haynes, Hiram Percy Maxim and Charles Brady King were all chasing the great automotive prize.

Ford's much-vaunted production process was actually an adaption of something that was already being used elsewhere: The assembly line had been used in the food processing industry in the Midwest United States since the 1870s. Ford himself is reputed to have toured Chicago's meat-packing plants in search of inspiration, noting that the meatpackers had an overhead trolley to speed up production. He also would have noted the operations of Sears, Roebuck's Chicago mail-order plant, which opened in 1906. At the time, it was the largest business building in the world, with three million square feet of floor space.

Time and time again, when you analyze the route to significant commercial success, you find that the magical, sexy stuff of innovation and entrepreneurialism isn't the main reason why an organization succeeded. Innovation and entrepreneurship are, of course, crucial, but successes like Ford and Amazon show us that there is a premium on making things happen and getting things done.

Unfortunatley, this is something modern organizations—backed by the full panoply of technological marvels at their disposal—remain poor at. A full 90 per cent of respondents to a 2017 global survey of 500 senior executives from companies with annual revenues of over $1 billion, conducted by the Economist Intelligence Unit (EIU), admitted that they had failed to reach their strategic goals because of flawed implementation. More than half (53 per cent) of respondents admitted that ineffective implementation of strategic initiatives had a profound impact on the organization's competitive advantage and performance. In addition, the 2017 Project Management Institute's Pulse of the Profession Survey found that for every $1 billion invested, $97 million is wasted through poor implementation performance.

The trouble with executing innovation is that, unlike formulating a clever strategy in a boardroom, it has to take shape in the real world. And that involves making hard decisions—and taking risks.

Can-do Capabilities

The relentless execution of innovation has four key characteristics:

Clarity

The beauty of relentless execution is that it concentrates managerial minds. At its best, it cuts away superfluous activities and targets all of an organization's resources on what really matters to get things done. While other auto-makers made their models more complicated and expensive, Henry Ford provided extreme clarity: the company would produce just one affordable car, in just one colour (black). This brand of smart simplicity is common in radical can-do organizations.

Consider the Chinese bike sharing company ofo (always in lower case to mimic the shape of a bicycle). "Ofo was created for sharing and aims to unlock every corner of the world by making bicycles accessible to everyone," says the company's website.

Ofo began life in 2014 when CEO Dai Wei and his co-founders saw an opportunity to leverage smart technology to improve cycling as a sustainable form of transportation. As students at Peking University, Wei and his partners convinced about 2,000 students to add their bicycles to a private registry. The registry could be accessed through a mobile app and allowed participants to use any registered bike, anywhere, at any time.

Today, ofo is operating in over 250 cities across 20 countries: China, Singapore, the UK, the U.S., Kazakhstan, Malaysia, Thailand, Austria, Japan, Russia, the Czech Republic, Italy, the Netherlands, Australia, Spain, Portugal, Israel, Hungary, India and France. It generates 32 million transactions daily and is valued at more than $3 billion. In 2017, it raised $700 million of funding from, among others, Alibaba, Hony Capital and CITIC Private Equity.

Once again, ofo is not breathtakingly original. Thanks to Airbnb and Uber, the sharing economy is an increasingly mainstream idea. The Velib bike-sharing network was introduced in Paris in 2007 and a similar program was introduced in London in 2010. Ofo's differentiator is its 'dockless' technology: Its eye-catching yellow bikes are hired through a smartphone app and can be picked up and dropped off anywhere that bike parking is allowed. In addition, Ofo does not require riders to pay a deposit before use. To access a bike, they can simply download the ofo app and unlock their nearest bike via Bluetooth. Once their ride is complete, users close the lock to complete their ride and make it available for the next person to use. Ofo uses 'geo-fencing' technology to ensure that riders use the bikes within the designated 'Home Zone' shown in the app.

Such simple, practical technology is driven by a bold sense of purpose. Ofo is engaged in a constant round of raising finance and opening in new territories. Success in any highly competitive global market requires constant momentum, relentless execution enabled by clarity of purpose.

Redefining Focus

"You have to continually prioritize," says David Marlow, company transformation lead at Bristol-Myers Squibb. "There are always competing activities going on in any organization and different functions wanting to do things with a different view of what to prioritize. This requires a senior management team to look at the enterprise level, at the overall amount of activities going on, and conduct a pri-

oritization assessment once or twice a year. This will ensure a focus on where the big value drivers are and that they are being properly resourced and prioritized."

Such focus is a powerful commercial weapon, but it needs to shift and change with time. Today's focus will not be appropriate tomorrow. This was something that Jack Welch practiced impressively as CEO of GE in the 1990s. Welch had a knack of distilling down his company's strategy to memorable phrases: 'Number one or two in every market'; 'getting the work out of the company'; 'dot-com your business'. Each slogan was repeated endlessly by Welch as he travelled through GE and beyond, providing focus for the company; but then he would always move on to provide the next focus.

A similar approach has been taken by the CEO of Chinese white- goods manufacturer Haier. As the company has evolved from a small local player into the world's leading white goods company, its CEO Zhang Ruimin has changed the company's focus time and time again.

"In the last three decades of dedication to entrepreneurship and innovation, Haier has been through five stages of strategic development, each of which represents a major endeavour of management innovation," he explains. "Our most recent strategic adjustment began in 2012, when we transitioned our company from being a traditional manufacturer to become a platform-based and networked organization in line with the lifestyle changes brought about by the internet."

During the 1980s, Haier dedicated itself to brand building. Its realization was that to compete internationally it had to raise the standards of its products. Zhang Ruimin proposed the principle of "a late starter with a high starting point". Famously, in 1985, after receiving letters from consumers complaining about quality problems with Haier refrigerators, Zhang joined employees in demolishing 76 of the sub-standard refrigerators with sledgehammers. The point was made: Haier had to match or exceed the highest quality standards.

In the 1990s, the company's focus shifted to diversification, with a variety of mergers and restructurings. The Haier refrigerator brand was extended to a range of other home appliances—washing machines, air conditioners, microwave ovens, televisions, computers and more. From there, Haier moved to focus on internationalization, with an emphasis on localized R&D, manufacturing and marketing. Its international moves were bold: Eschewing easier and closer markets, it headed to the United States and Europe, where markets were highly competitive and quality expectations high. Following this stage, the focus was on was Haier's global brand stage—it's acceptance as a powerful brand presence worldwide.

In December 2012, Haier announced its entrance into a fifth development stage: networking strategy. "The 'Internet mindset' for a business should be zero dis-

tance and networked mindset," Ruimin has explained. "The Internet has eliminated physical distance and enabled businesses to become networked. The competitive tension among a company, its employees and its partners should be defused with the aim of building a collaborative, win-win ecosystem."

Commitment to Change

For companies dedicated to relentless execution, the only danger is to press pause. Yet this is a fairly regular occurrence. As small entrepreneurial companies expand into larger ones, there is a temptation to 'bring the grown-ups in' to add bureaucracy and processes. Sometimes, this works, but it can bring an entrepreneurial rocket to an abrupt halt. Just look at Steve Jobs' initial departure from Apple as the company sought to bring management discipline to bear.

A commitment to change must be real and constant. The challenge of change is to instigate it from a position of strength. Repeatedly, companies attempt to change things as their performance deteriorates or their market strength evaporates. Not Haier nor the other relentless can-do companies. Indeed, the more successful they become, the greater their apparent appetite for change.

This continuous appetite for change is exemplified by Netflix CEO Reed Hastings. "You have to fight the idea that as you get bigger, your culture gets worse. At Netflix, we're significantly better [than we were] because we have more brains thinking about the problem. If you have 1,000 really thoughtful people thinking about how to improve, you'll make a lot more progress than if you have 100," he says. "Some companies operate by the principle of the product genius at the top. There's this whole motif that to be a great CEO you have to be a great product person. That's intoxicating and fun, but you build in incredible amounts of dependence on yourselves. You're much stronger building a distributed set of great thinkers."

In 2010, Netflix began operating in Canada; in 2011, Latin America, Central America and the Caribbean; in 2012, the UK, Ireland and Scandinavia; in 2013, the Netherlands; in 2014, Austria, Germany, France, Belgium, Luxembourg and Switzerland; in 2015, Australia, New Zealand, Japan, China, Italy, Portugal and Spain; and in 2016 it expanded into more Asian countries. "You are witnessing the birth of a global TV network," proclaimed Hastings as another 130 countries were added to the company's reach to take the global figure to nearly 200 countries from Afghanistan through to Zimbabwe.

Radical Failure

Of course, with a radical can-do mindset comes the inevitability of failure. Role modelling failure starts at the top of any organization, division, team or small company. "If we're not making mistakes, we're not trying hard enough," observed James Quincey when he became CEO of Coca-Cola in 2017. Amazon's Jeff Bezos has been similarly vocal in making it clear that failing is an integral part of succeeding. "If you're going to take bold bets, they're going to be experiments. And if they're experiments, you don't know ahead of time if they're going to work. Experiments are by their very nature prone to failure. But a few big successes compensate for dozens and dozens of things that didn't work."

At Netflix, where the culture is built around what they call 'radical candor', Hastings is an outspoken champion of failure. "You should have more things that don't work out," he has observed. "As you grow, the drive towards conformity is substantial. As a leader, you want to drive people to take more risks." Speaking at a recent conference, Hastings lamented: "Our hit ratio is way too high right now. I'm always pushing the content team. We have to take more risks. We have to try more crazy things, because we should have a higher cancel rate, overall."

Getting Close to Customers

"Innovators and entrepreneurs rarely fail because their initial idea was stupid," observes Alex Osterwalder, co-author of Business Model Generation. "They don't succeed because they fail to listen to the reality of the market. They fail to iterate their idea and adapt their value proposition and business model until it's scalable and profitable."

The radical can-do mindset is not about pressing ahead and blindly doing things for the sake of doing them. As indicated, it requires clarity and focus, but it also demands an in-depth knowledge of what your customers want and what they aspire to. In the most successful projects we have witnessed, there is a strong correlation between employee engagement and awareness of what customers want and need.

"Insight into customer needs and competitor moves, combined with the speed and agility to capitalize on this insight, will be increasingly critical for competitive success," predict Perry Keenan and his colleagues at the Boston Consulting Group.

It is especially challenging for companies in fast-moving markets to connect with the future aspirations and needs of customers. It is interesting to see the work of the modern-day Ford Motor Corporation in this area—given the identification with customers exemplified by its founder. "Henry Ford's mission was to help people move. That's still at our core, but now we're looking at the larger scope of

what 'mobility' means," observes Jamel Seagraves, an advanced research engineer at Ford.

For Ford, re-connecting with this original purpose has brought the company to Silicon Valley. Among its interesting takes on 'its place in the world' is that tech companies are increasingly automotive suppliers. In 2015, it opened the Ford Innovation and Research Centre in Palo Alto. The Center is led by a former Apple engineer and is charged with exploring the future of mobility with a team of 160 researchers, engineers and scientists. Among its projects are autonomous vehicles and helping cyclists and motorists share roads.

In closing

Getting things done with a relentless can-do attitude demands a degree of boldness and bravery that few executives and organizations are encouraged to demonstrate. These characteristics are founded on a deeply-held belief that the status quo is not good enough—that things can and must get better; that getting out there and connecting with people is preferable to building internal walls; and that failure is inevitable along the way. As indicated by the stories of Amazon, ofo, Netflix, Haier and many others, fortune truly favours the brave.

Authors

Ricardo Viana Vargas is Executive Director of the Brightline Initiative, a not-for-profit coalition of global organisations dedicated to deliver insights to successfully bridge the gap between the design and the delivery of strategy. He specialises in project management and strategy implementation. Over the past 20 years, he has been responsible for more than 80 major transformation projects in several countries, covering an investment portfolio of over US$20 billion. Between 2012 and 2016, he was director for infrastructure and project management at the United Nations (UNOPS). Ricardo has written fifteen books on the subject, available in several languages.

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1 https://www.brightline.org

RICARDO VARGAS

TEN QUESTIONS TO HELP YOU TURN STRATEGY INTO REALITY

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Sustainable growth depends on delivering the right strategies the right way. Yet this is something that organisations appear ill-equipped to do. Our work at the Brightline Initiative is examining[1] what causes the gap between strategy and implementation and how it can be closed. Our research suggests that business leaders need to answer ten key questions for their strategies to more effectively make the leap from design to delivery.

1. Is delivery as important to you as design?

Strategy design can be an exciting process. It is cerebral, based on marshalling facts and figures, views and opinions, hunches and suggestions. Creating a coherent and persuasive strategy is part art and part science. It is demanding, difficult and vitally important, but without implementation it is nothing.

In a 2017 Economist Intelligence Unit global survey[2] of 500 senior corporate executives, over 90 per cent admitted they failed to reach all of their strategic goals because of flawed implementation.

2. Does the leadership team take responsibility for delivery too?

Once you have defined and clearly communicated the strategy, your responsibility shifts to tracking implementation. You need to know where in your organisation change happens and who manages the programs that drive change. You proactively address emerging gaps and challenges that may impact delivery. Without this discipline, your strategy has little chance of success.

3. Do you mobilise the right resources?

Consulting firms and more fluid organisations are adept at ensuring that their best people are working on the projects that need them most. In contrast, hierarchical and other organisational structures can limit mobility and many organisations struggle to release their best minds to become involved with implementing key strategies. "Always put your best talent on critical initiatives and make sure that you reward them accordingly, but more importantly make sure that they will have roles after the completion of the assignment," advises David Marlow, company transformation lead at Bristol-Myers Squibb, in his article[3] at the Strategy@ Work book.

1 https://www.brightline.org/resources/economist-qa-preventing-a-frozen-middle/
2 https://www.brightline.org/resources/eiu-report/
3 https://www.brightline.org/resources/thinkers50-strategy-at-work-book/

4. Do you leverage insight on customers and competitors?

Organisations atrophy when they lose touch with their customers, whereas the best leaders are constantly seeking insights from customers and competitors. In the EIU survey 53 per cent of companies said that changing customer expectations/demands impeded implementation. As a result, the majority monitored customer trends. But only one in five reported having effective feedback loops to use all of this data in strategy delivery. In a Harvard Business Review article[4], Amy Edmondson and Paul Verdin argue that customer input – at all stages – is a vital lubricant of strategy and execution. It creates what they call "strategy as learning".

5. Is your implementation bold, focused and as simple as possible?

Delivery is complex – often global, always interconnected. To succeed the constant emphasis must be on boldness, focus and simplicity. The Boston Consulting Group talks of "smart simplicity"[5]. This involves empowering people sufficiently for the requirements of their jobs by giving them the right resources, removing unnecessary constraints, and aligning interests by consequences to actions and results.

6. Do you promote team engagement and cross-business cooperation?

Support and understanding of the strategy throughout the organisation: Middle and line managers must be engaged and activated as strategy champions rather than just as managers and supervisors. In the EIU survey, 62 per cent of respondents said that lack of buy-in from middle managers, line managers or both created a significant barrier to strategy implementation at their organisations.

Second the understanding that teams are the means by which strategies are delivered. The Boston Consulting Group refers to *performance integrity*[6]. By this it means a highly motivated and thoughtful project team with a bias for action, clear on its objectives, with a strong leader and sufficient member resources, plus the right mix of skills for the effort.

4 https://hbr.org/2017/11/your-strategy-should-be-a-hypothesis-you-constantly-adjust
5 https://www.bcg.com/en-us/capabilities/smart-simplicity/smart-simplicity-concept.aspx
6 https://hbr.org/2005/10/the-hard-side-of-change-management

7. Do you own the decisions you make?

Commit to making strategic decisions rapidly. Move quickly to correct course, reprioritise, and remove roadblocks. Accept that you likely won't have all the information you want, and rely on those you can trust to deliver sufficient reliable input to allow thoughtful decisions. Consider and address risks and interdependencies explicitly—both upfront and regularly throughout delivery. Build a lean and powerful governance structure to reinforce accountability, ownership, and a bias towards action, based on agreed metrics and milestones.

8. Do you check ongoing initiatives before committing to new ones?

Organisations tend to overburden people with strategic initiatives of one form or another, creating change fatigue. You must regularly evaluate your portfolio of strategic initiatives. Add new initiatives in response to new opportunities, but first be sure you understand both the existing portfolio and your organisation's capacity to deliver change. Agility, the organisational capability to quickly adapt strategy in response to external and internal changes, plays an important role in both the governance and management of any portfolio of strategic initiatives.

9. Do you develop robust plans but allow for missteps?

We live in fast-moving times. Even the most far-reaching and elaborate strategies must contain room for learning and realignment. Strategy planning cycles are more rapid, dynamic, and agile than in the past. Delivery teams must be able to experiment and learn in an environment where it is safe to fail fast. In practice, this means you must discuss challenges openly, and adjust the plan as needed for success. Learn to reward failure, or at least accept it as a valuable input.

In agile organisations it is common to have frequent interactions between teams and leaders, to review and understand what went wrong, what worked well and what needs to be improved. It is a powerful iterative process. This is not simply about communication, it is about interaction up, down and across the company.

Interestingly, what appears to be evolving is acceptance of the need of a hybrid approach to strategy. The intention is to manage the current business and operations while dynamically seeking out the next disruptive idea. This can be seen at Volkswagen Group according to this report[7]. The company's chief strategy officer Thomas Sedran talks of a "two-speed organisation" – "One part goes with proven

7 https://s3.us-east-2.amazonaws.com/brightline-website/downloads/reports/brightline-economist-report.pdf?utm_source=resource-page&utm_medium=skip-link

processes that lead to reliable products. This is necessary for those developing vehicles because delivering an unsafe one can cost you the company. For the other part, where you need to be much quicker, but where the impact of a failure is less severe, you need to be agile and have different planning and execution processes."

10. Do you celebrate success and recognise those who have done good work?

Success in organisations is often whispered rather than celebrated. If strategy delivery is to become embedded in any organisational culture, successes must be widely and wildly celebrated. It is notable how adept the best business leaders are at acknowledging good work. They tend to have developed a personal means of communicating great work – a handwritten note, a phone call.

Any leader who can answer these ten questions in the affirmative is well placed to translate strategy into delivery. Even failing to deal with the issues raised by one of the questions can fatally handicap even the most brilliant strategy.

Notes:

This post gives the views of its authors, not the position of LSE Business Review or the London School of Economics.

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8 https://www.brightline.org

RICARDO VARGAS

APPLYING NEURAL NETWORKS AND ANALOGOUS ESTIMATING TO DETERMINE THE PROJECT BUDGET

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Orlando – Florida – USA – 2015

Abstract

This paper aims to discuss the use of the Artificial Neural Networks (ANN) to model aspects of the project budget where traditional algorithms and formulas are not available or not easy to apply. Neural networks use a process analogous to the human brain, where a training component takes place with existing data and subsequently, a trained neural network becomes an "expert" in the category of information it has been given to analyse. This "expert" can then be used to provide projections given new situations based on an adaptive learning (STERGIOU & CIGANOS, 1996).

The article also presents a fictitious example of the use of neural networks to determine the cost of project management activities based on the complexity, location, budget, duration and number of relevant stakeholders. The example is based on data from 500 projects and is used to predict the project management cost of a given project.

Related Podcasts

♫ Importance of the Work Breakdown Structure (WBS) to the Project Cost Management
http://rvarg.as/et

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http://rvarg.as/d0

♫ Cost Estimating – Part 3 of 3
http://rvarg.as/d2

♫ Applying Neural Networks and Analogous Estimating to Determine the Project Budget
http://rvarg.as/nn

Artificial Neural Networks (ANN)

Some categories of problems and challenges faced in the project environment may depend on many subtle factors that a computer algorithm cannot be created to calculate the results (KRIESEL, 2005). Artificial Neural Networks (ANN) are a family of statistical learning models inspired by the way biological nervous systems, such as the brain, process information. They process records one at a time, and "learn" by comparing their classification of the record with the known actual classification of the record.

The errors from the initial classification of the first record are fed back into the network, and used to modify the networks algorithm the second time around, and so on for a large number of iterations in a learning process in order to predict reliable results from complicated or imprecise data (STERGIOU & CIGANOS, 1996) (Exhibit 01).

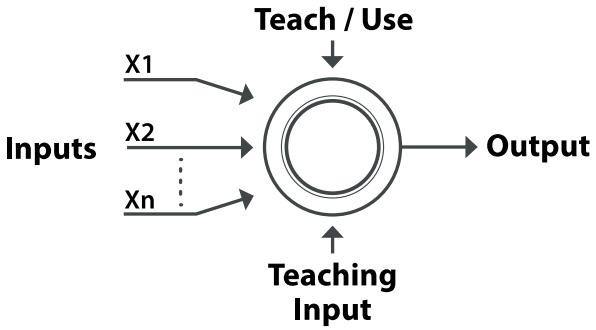

Exhibit 01 - Artificial Neural Networks Architecture (adapted from MCKIM, 1993 and STERGIOUS & CIGANOS, 1996)

Some typical applications of ANN are

- *handwriting recognition,*
- *stock market prediction,*
- *image compression,*
- *risk management,*
- *sales forecasting*
- *industrial process control.*

The mathematical process behind the calculation uses different neural network configurations to give the best fit to predictions. The most common network types are briefly described below.

Probabilistic Neural Networks (PNN) – Statistical algorithm where the operations are organized in multi-layered feedforward network with four layers (input, pattern, summation and output). It is fast to be trained but it has a slow execution and requires large memory. It is also not as general as the feedforward networks (CHEUNG & CANNONS, 2002).

Multi-Layer Feedforward Networks (MLF) – MLF neural networks, trained with a back-propagation learning algorithm (Exhibit 02). They are the most popular neural networks (SVOZIL, KVASNIČKA & POSPÍCHAL, 1997).

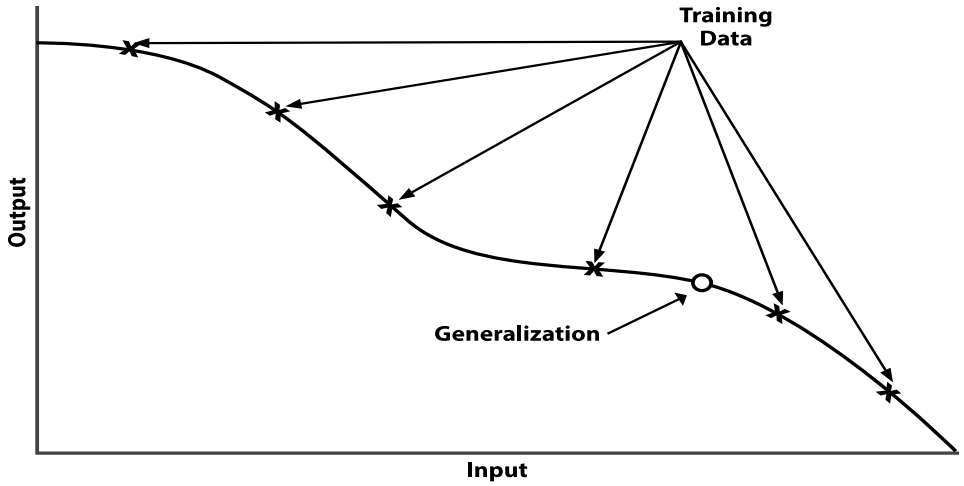

Exhibit 02 - Training data and generalization in a Multi-Layer Feedforward Network (SVOZIL, D , KVASNIČKA, V. & POSPÍCHAL, J. , 1997)

Generalized Regression Neural Networks (GRNN) – Closely related to PNN networks, it is a memory-based network that provides estimates of continuous variables. It is a one-pass learning algorithm with a highly parallel structure. The algorithmic form can be used for any regression problem in which an assumption of linearity is not justified (SPECHT, 2002).

Analogy Process and Data Set

One of the key factors of the Neural Networks is the data set used on the learning process. If the data set is not reliable, the results from the networks calculations will not be reliable. The use of Artificial Neural Networks can be considered one kind of analogy (BAILER-JONES & BAILER-JONES, 2002).

Analogy is a comparison between two or more elements, typically for the purpose of explanation or clarification (Exhibit 03). One of the most relevant uses of the analogy is to forecast future results based on similar results obtained in similar conditions (BARTHA, 2013). The challenge is to understand what a similar condition is. Projects in the past can be a reference for future projects if the underlining conditions where they were developed still exist in the project subject to the analysis.

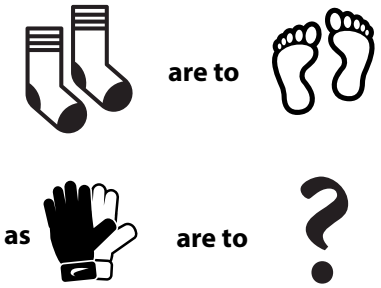

Exhibit 03 - Simple analogy example "sock are to feet as gloves are to hands" (Adaptedfrom Spitzig, 2013)

One of the most relevant aspects of the analogy is related to the simple process of estimation based on similar events and facts. This process reduces the granularity of all calculations, where the final project costs can be determined by a set of fixed finite variables.

Data Set, Dependent and Independent Categories and Numeric Variables

The first step to develop an Artificial Neural Network is to prepare the basic data set that will be used as a reference for the "training process" of the neural network. It is important to highlight that usually the right dataset is expensive and time consuming to build (INGRASSIA & MORLINI, 2005). A dataset is composed by a set of variables filled with information that will be used as a reference. These references are called cases (Exhibit 04).

		VARIABLES					
		INDEPENDENT VARIABLES					DEPENDENT VARIABLE (OUTPUT)
		V1	V2	V3	•••••	Vn	V'1
CASES	Case 1						
	Case 2						
	Case 3						
	⋮						
	Case n						

Exhibit 04 - Structure of a basic dataset

The most common variables types are

Dependent Category – dependent or output variable whose possible values are taken from a set of possible categories; for example Yes or No, or Red, Green or Blue.

Dependent Numeric – dependent or output variable whose possible values are numeric.

Independent Category – an independent variable whose possible values are taken from a set of possible categories; for example Yes or No, or Red, Green or Blue.

Independent Numeric – an independent variable whose possible values are numeric.

In the project environment, several variables can be used to calculate the project budget. Some common examples are

Complexity – Level of complexity of the project (Low, Medium, High). Usually it is an independent category.

Location – Location where the project works will happen. Associated to the complexity of the works and logistics. Most of the time it is an independent category.

Budget – Planned budget of the project. It is a numeric variable that can be independent or dependent (output).

Actual Cost – Actual Expenditure of the project. It is most of the time an independent numeric variable.

Cost Variance – The difference between the budget and the actual cost. It is a numeric variable that can be independent or dependent (output)

Baseline Duration – Duration of the project. Independent numeric variable.

Actual Duration – Actual duration of the project. Usually an independent numeric variable.

Duration Variance – The difference between the baseline duration and the actual duration.

Type of Contract – Independent category variable that defines the type of the contract used for the works in the project (ie: Fixed Firm Price, Cost Plus, Unit Price, etc).

Number of Relevant Stakeholder Groups – Independent numeric variable that reflect the number of relevant stakeholder groups in the project.

Some examples of input variables are presented at the Exhibit 05, 06 and 07.

INPUT VARIABLES	DESCRIPTION	UNIT	RANGE
PWA	Predominant Work Activity	Category	New Construction Asphalt or Concrete
WD	Work Duration	month	14–30
PW	Pavement Width	m	7–14
SW	Shoulder Width	m	0–2
GRF	Ground Rise Fall	nillan	2–7
ACG	Average Site Clear/Grub	m^2/kin	12605–30297
EWV	Earthwork Volume	m^3/kin	13134–31941
SURFCLASS	Surface Class	Category	Asphalt or Concrete
BASEMATE	Base Material	Category	Crushed Stone or Cement Stab.
	OUTPUT VARIABLE		
USDPERKM	Unit Cost of New Construction Project	US Dollars (2000)	572.501.64-4.006.103.95

Exhibit 05 – Example of Variables in Road Construction (SODIKOV, 2005)

DESCRIPTION	RANGE
Ground floor	100–3668 m^2
Area of the typical floor	0–2597 m^2
No. of storeys	1–8
No. of columns	10–156
Type of foundation	1 – isolated
	2 – isolated and combined
	3 – raft or piles
No. of elevators	0–3
No. of rooms	2–38
Cost of structural skeleton	6,282469,680 USD

Exhibit 06 – Example of key variables for buildings (ARAFA & ALQEDRA, 2011)

PROJECT CHARACTERISTICS	UNIT	TYPE OF INFORMATION	DESCRIPTORS
Gross Floor Area (GFA)	m^2	Quantitative	n.a
Principal structural material	No unit	Categorical	1 – steel
			2 – concrete
Procurement route	No unit	Categorical	1 – traditional
			2 – design and construct
Type of work	No unit	Categorical	1 – residential
			2 – commercial
			3 – office
Location	No unit	Categorical	1 – central business district
			2 – metropolitan
			3 – regional
Sector	No unit	Categorical	1 – private sector
			2 – public sector
Estimating method	No unit	Categorical	1 – superficial method
			2 – approximate quantities
Number of storey	No unit	Categorical	1 – one to two storey(s)
			2 – three to seven storeys
			3 – eight storeys and above
Estimated Sum	Cost/m^2	Quantitative	n.a

Exhibit 07 – Example of variables for a building construction (AIBINU, DASSANAYAKE & THIEN, 2011)

Training Artificial Neural Networks

When the dataset is ready the network is ready to be trained. Two approaches can be used for the learning process: supervised or adaptive training.

In the supervised training, both inputs and outputs are provided and the network compares the results with the provided output. This allows the monitoring of how well an artificial neural network is converging on the ability to predict the right answer.

For the adaptive training, only the inputs are provided. Using self-organization mechanisms, the neural networks benefits from continuous learning in order to face new situations and environments. This kind of network is usually called self-organizing map (SOM) and was developed by Teuvo Kohonen (KOHONEN, 2014).

One of the biggest challenges of the training method is to decide on which network to use and the runtime process in the computer. Some networks can be trained in seconds but in some complex cases with several variables and cases, hours can be needed just for the training process.

The results of the training process are complex formulas that relate the input or independent variables with the outputs (dependable variables) like the graph presented in the Exhibit 2.

Most of the commercial software packages usually test the results of the training with some data points to evaluate the quality of the training. Around 10 to 20% of the sample is used for testing purposes (Exhibit 08).

Person	Gender	Age	Income	Alcohol	Exercise	Smoke	Blood pressure	Tag Used	Prediction	Good/Bad	Residual
1	Female	52	84800	75	7	49	53	train			
	Female	43	118570	75	70	49					
2	Female	28	172600	7	70	0	27	test	24,01	Good	2,99
3	Male	64	274500	31	19	24	78	test	81,80	Good	-3,80
4	Male	57	103600	50	0	78	94	train			
5	Female	37	107400	31	25	42	41	train			
6	Male	58	108500	57	0	62	72	train			
7	Male	54	156700	42	31	24	41	test	42,14	Good	-1,14
8	Male	26	71300	0	40	14	17	train			
9	Female	44	101300	54	24	56	49	train			
10	Male	31	100200	13	35	27	36	train			
11	Male	46	113100	39	5	75	67	train			
12	Male	65	122500	77	0	89	92	train			
13	Female	52	118900	62	21	67	60	test	63,75	Good	-3,75
14	Male	30	192600	78	83	65	71	test	82,75	Good	-11,75
15	Male	58	150600	52	1	61	65	train			
16	Male	42	66400	67	13	62	48	train			
17	Male	60	149600	63	13	69	70	test	72,05	Good	-2,05
18	Female	46	176100	39	60	46	54	train			

Exhibit 08 – Training results example to forecast the bloody pressure where some data is used for testing the network results (Palisade Neural Tools software example)

Prediction Results

After the training, the model is ready to predict future results. The most relevant information that should be a focus of investigation is the contribution of each individual variable to the predicted results (Exhibit 09) and the reliability of the model (Exhibit 10).

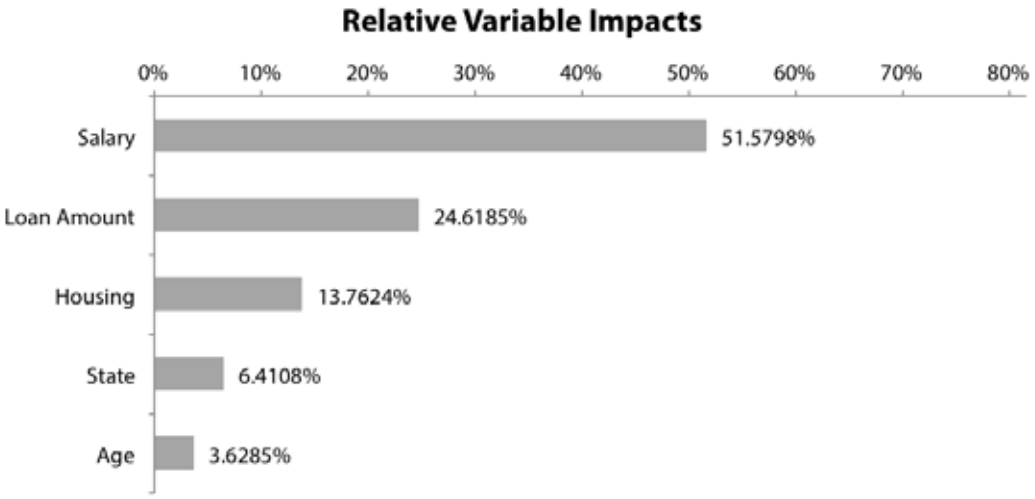

Exhibit 09 - Example of Relative Variable impacts, demonstrating that the Salary variable is responsible for more than 50% of the impact in the dependent variable (Palisade Neural Tools software example)

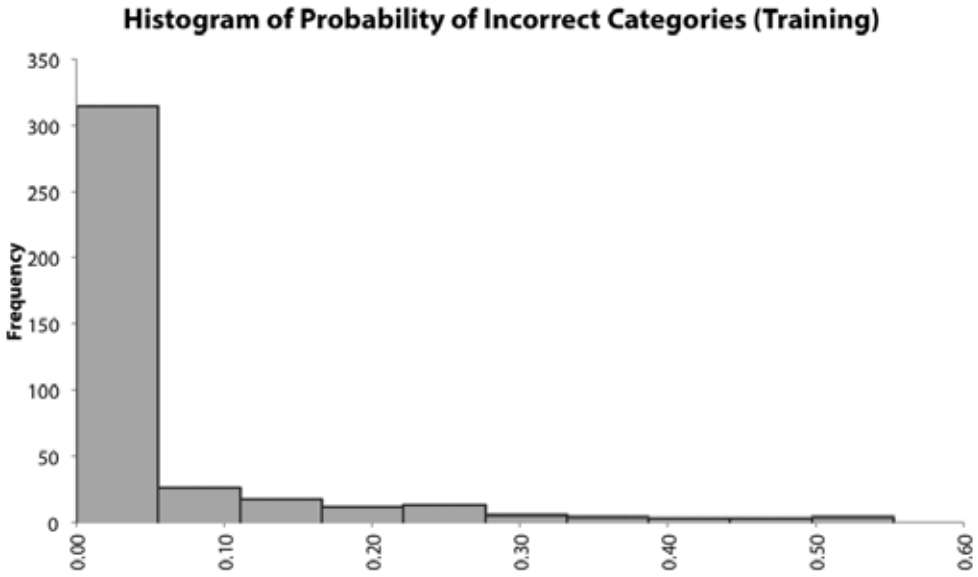

Exhibit 10 – Example of histogram of Probability of Incorrect Categories showing a chance of 30% that 5% of the prediction can be wrong (Palisade Neural Tools software example)

It is important to highlight that one trained network that fails to get a reliable result in 30% of the cases is much more unreliable than another one that fails in only 1% of the cases.

Example of Cost Modeling using Artificial Neural Networks

In order to exemplify the process, a fictitious example was developed to predict the project management costs on historical data provided by 500 cases[1]. The variables used are described in the Exhibit 11.

NAME	DESCRIPTION	VARIABLE TYPE
Project ID	ID Count of each project in the dataset	–
Location	Location where the project was developed (local or remote sites)	Independent Category
Complexity	Qualitative level of project complexity (Low, Medium and High)	Independent Category
Budget	Project Budget (between $500,000 and $2,000,000)	Independent Numeric
Duration	Project Duration (Between 12 and 36 months)	Independent Numeric
Relevant Stakeholder Groups	Number of relevant stakeholder groups for communication and monitoring (between 3 and 5)	Independent Category
PM Cost	Actual cost of the project management activities (planning, budgeting, controlling)	Dependent Numeric (Output)

Exhibit 11 – Variables used on the example dataset

The profiles of the cases used for the training are presented at the Exhibit 12, 13, 14, 15 and 16 and the full dataset is presented in the Appendix.

Location	Projects	%
Local	250	50.00%
Remote	250	50.00%
Total	**500**	**100.00%**

Exhibit 12 – Distribution of cases by Location

Complexity	Projects	%
Low	201	40.20%
Medium	176	35.20%
High	123	24.60%
Total	**500**	**100.00%**

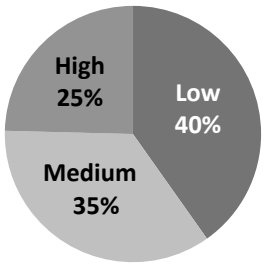

Exhibit 13 – Distribution of cases by Complexity

1 The example was developed to demonstrate the use of the artificial networks and was not built from actual data. All data used is fictitions and should be considered only as an example.

Budget Range	Projects	%
500000-750000	158	31.60%
750000-1000000	111	22.20%
1000000-1250000	99	19.80%
1250000-1500000	74	14.80%
1500000-1750000	43	8.60%
1750000-2000000	15	3.00%
Total	**500**	**100.00%**

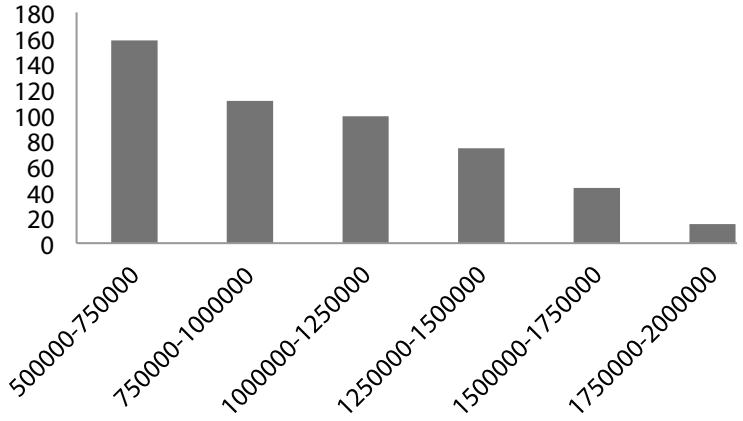

Exhibit 14 – Distribution of cases by Project Budget

Duration Range	Projects	%
12-17	145	29.00%
18-23	189	37.80%
24-29	96	19.20%
30-36	70	14.00%
Total	**500**	**100.00%**

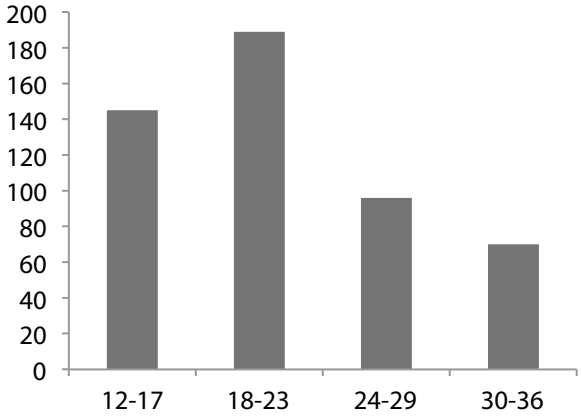

Exhibit 15 – Distribution of cases by Project Duration

Stakeholder Groups	Projects	%
3	238	47.60%
4	158	31.60%
5	104	20.80%
Total	**500**	**100.00%**

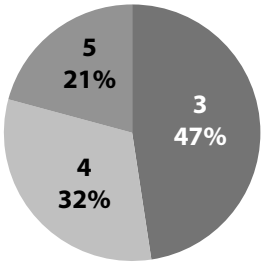

Exhibit 16 – Distribution of cases by Relevant Stakeholder Groups

The training and the tests were executed using the software Palisade Neural Tools. The test was executed in 20% of the sample and a GRNN Numeric Predictor. The summary of the training of the ANN is presented at the Exhibit 17.

NET INFORMATION	
Name	Net Trained on Project Data
Configuration	GRNN Numeric Predictor
Location	This Workbook
Independent Category Variables	3 (Location, Complexity, Relevant Stakeholder Groups)
Independent Numeric Variables	2 (Budget, Duration)
Dependent Variable	Numeric Var. (PM Cost)

TRAINING	
Number of Cases	400
Training Time	00:00:38
Number of Trials	75
Reason Stopped	Auto-Stopped
% Bad Predictions (30% Tolerance)	0.0000%
Root Mean Square Error	944.70
Mean Absolute Error	706.47
Std. Deviation of Abs. Error	627.18

PREDICTION	
Number of Cases	1
Live Prediction Enabled	YES

TESTING	
Number of Cases	100
% Bad Predictions (30% Tolerance)	0.0000%
Root Mean Square Error	1,508.66
Mean Absolute Error	1,170.24
Std. Deviation of Abs. Error	952.16

DATA SET	
Name	Project Data
Number of Rows	501
Manual Case Tags	NO

VARIABLE IMPACT ANALYSIS	
Budget	54.3124%
Duration	25.4821%
Location	8.2800%
Complexity	7.0677%
Relevant Stakeholder Groups	4.8578%

Exhibit 17 – Palisade Neural Tools Summary Table

The relative impact of the five independent variables are described at the Exhibit 18, demonstrating that more than 50% of the impact in the Project Management cost is related to the project budget in this fictitious example.

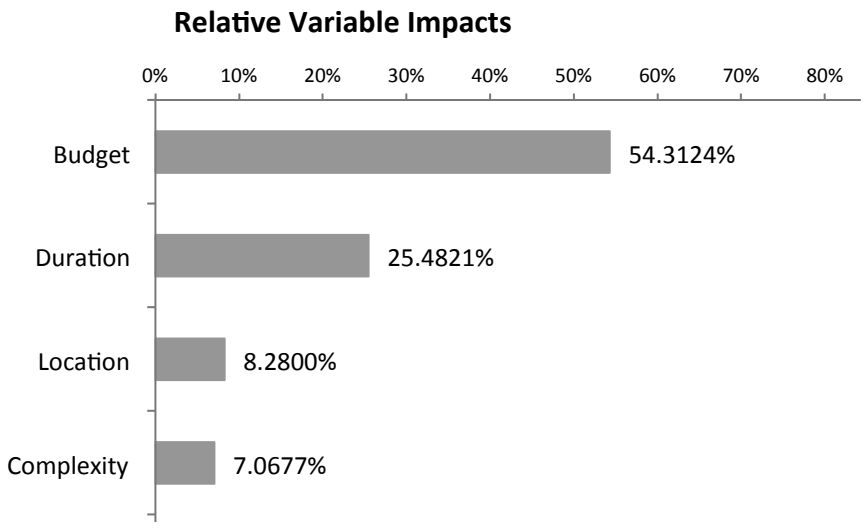

Exhibit 18 – Relative Variable Impacts

The training and tests were used to predict the Project Management Cost of a fictitious project with the following variables.

NAME	VARIABLE TYPE
Location	Local Project
Complexity	High Complexity
Budget	$810,756
Duration	18 months
Relevant Stakeholder Groups	5 Stakeholder groups
Relevant Stakeholder Groups	Independent Category
PM Cost	Dependent Numeric (Output)

Exhibit 19 – Basic information of a future project to be used to predict the Project Management costs

After running the simulation, the Project Management cost predictions based on the patterns in the known data is $24,344.75, approximately 3% of the project budget.

Conclusions

The use of Artificial Neural Networks can be a helpful tool to determine aspects of the project budget like the cost of project management, the estimated bid value of a supplier or the insurance cost of equipment. The Neural Networks allows some precise decision making process without an algorithm or a formula based process.

With the recent development of software tools, the calculation process becomes very simple and straightforward. However, the biggest challenge to produce reliable results lies in the quality of the known information. The whole process is based on actual results, and most of the time the most expensive and laborious part of the process is related to getting enough reliable data to train and test the process.

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Appendix – Example Dataset

LOCATION	COMPLEXITY	BUDGET	DURATION	RELEVANT STAKEHOLDER GROUPS	PM COST	% PM COST	TAG USED	TEST	GOOD OR BAD	RESIDUAL	%
Remote	Medium	703,998.33	17	3	21,547.87	3.06%	train				
Remote	High	902,327.29	17	5	33,934.58	3.76%	test	33,275.83	Good	658.75	1.94%
Local	Low	904,824.77	27	3	14,789.98	1.63%	train				
Local	Low	640,833.02	17	3	15,128.69	2.36%	train				
Local	Low	683,992.89	16	3	16,985.82	2.48%	test	17,240.60	Good	-254.78	-1.50%
Remote	High	1,467,802.93	20	5	49,416.03	3.37%	train				
Remote	High	569,532.07	26	4	16,983.74	2.98%	train				
Remote	Low	1,235,140.98	12	4	47,896.02	3.88%	train				
Remote	Low	1,254,182.69	13	4	45,954.54	3.66%	test	43,510.55	Good	2,443.99	5.32%
Local	Low	634,127.64	16	3	15,747.50	2.48%	test	16,691.89	Good	-944.38	-6.00%
Remote	High	1,310,397.18	25	3	34,507.13	2.63%	train				
Local	High	1,045,689.31	15	3	31,603.05	3.02%	test	29,729.94	Good	1,873.11	5.93%
Local	Medium	1,070,909.21	20	5	27,486.67	2.57%	train				
Remote	High	1,069,089.15	25	4	31,359.95	2.93%	train				
Remote	Low	600,174.43	14	4	21,491.96	3.58%	train				
Remote	Low	1,274,790.04	17	4	39,018.57	3.06%	test	37,604.96	Good	1,413.61	3.62%
Remote	Low	1,333,972.58	13	5	50,212.10	3.76%	train				
Remote	High	1,600,399.26	16	4	58,948.04	3.68%	train				
Remote	High	1,208,443.26	32	3	28,297.71	2.34%	train				
Local	Low	1,618,395.90	12	3	49,810.63	3.08%	test	43,252.94	Good	6,557.69	13.17%
Remote	Low	580,524.22	15	3	18,125.26	3.12%	test	18,178.96	Good	-53.70	-0.30%
Remote	Low	1,277,669.74	26	4	30,434.75	2.38%	train				
Local	High	1,465,538.27	27	5	35,679.52	2.43%	test	36,732.46	Good	-1,052.93	-2.95%
Local	High	534,389.92	19	5	16,322.33	3.05%	test	16,106.84	Good	215.49	1.32%
Local	Low	1,110,809.34	19	4	26,152.74	2.35%	test	24,588.71	Good	1,564.03	5.98%
Remote	Low	938,755.52	14	4	33,616.39	3.58%	train				
Remote	Medium	573,363.07	22	5	17,287.77	3.02%	train				
Remote	High	1,030,776.33	24	3	27,716.43	2.69%	train				
Remote	High	961,099.65	13	5	41,943.37	4.36%	train				
Local	Medium	765,884.98	16	3	20,551.25	2.68%	train				
Remote	High	1,074,273.06	15	3	37,838.28	3.52%	train				
Local	Low	762,219.86	16	3	18,928.46	2.48%	train				
Local	Low	964,410.00	20	3	19,931.14	2.07%	train				
Remote	Low	911,404.26	24	4	23,595.24	2.59%	test	22,578.66	Good	1,016.59	4.31%
Remote	High	1,930,468.28	20	3	57,270.56	2.97%	train				
Remote	High	981,611.00	23	5	31,895.24	3.25%	train				
Local	Low	1,126,200.40	21	3	21,254.80	1.89%	test	22,151.95	Good	-897.15	-4.22%
Local	High	708,383.15	21	3	17,619.63	2.49%	train				
Local	Low	852,403.45	17	4	22,680.62	2.66%	train				
Remote	Low	816,178.39	16	3	24,349.32	2.98%	train				

LOCA-TION	COMPLE-XITY	BUDGET	DURA-TION	RELE-VANT STAKE-HOLDER GROUPS	PM COST	% PM COST	TAG USED	TEST	GOOD OR BAD	RESIDUAL	%
Remote	Low	1,151,686.39	22	5	31,270.03	2.72%	train				
Remote	High	624,255.72	13	3	24,746.14	3.96%	train				
Remote	High	531,076.00	25	3	14,516.08	2.73%	train				
Local	Low	1,219,803.85	21	5	27,900.59	2.29%	train				
Remote	Low	1,359,202.77	17	4	41,602.27	3.06%	train				
Local	Low	693,228.75	15	3	18,178.00	2.62%	train				
Local	High	801,510.16	28	3	16,755.38	2.09%	train				
Local	High	511,096.39	26	5	13,196.77	2.58%	train				
Local	Low	590,242.71	15	5	17,838.45	3.02%	train				
Remote	Low	1,116,386.68	17	4	34,170.19	3.06%	train				
Remote	Medium	1,123,846.83	23	4	30,897.64	2.75%	test	31,578.29	Good	-680.64	-2.20%
Remote	High	547,802.19	23	5	17,799.60	3.25%	train				
Remote	High	966,086.13	15	4	37,892.04	3.92%	train				
Local	Medium	1,273,716.73	22	3	25,667.32	2.02%	train				
Local	High	778,993.21	20	4	22,331.14	2.87%	test	22,044.71	Good	286.43	1.28%
Local	Low	894,732.93	19	3	19,276.00	2.15%	train				
Remote	Low	1,171,008.92	19	4	33,425.11	2.85%	train				
Remote	Low	551,582.86	21	4	15,374.28	2.79%	train				
Remote	High	546,599.66	29	4	15,574.95	2.85%	train				
Remote	High	1,789,071.54	28	4	49,923.62	2.79%	train				
Local	Low	1,323,310.37	28	3	19,723.63	1.49%	train				
Remote	Low	845,707.18	20	3	21,706.48	2.57%	train				
Local	Medium	782,095.09	21	5	20,235.16	2.59%	train				
Local	Medium	512,318.31	18	4	14,098.24	2.75%	train				
Remote	High	1,056,680.60	23	4	32,221.10	3.05%	train				
Local	Low	1,399,151.60	12	4	47,260.23	3.38%	train				
Remote	Low	1,629,835.05	19	4	46,521.78	2.85%	train				
Local	Low	1,747,728.47	19	5	42,896.00	2.45%	train				
Local	High	584,824.62	24	4	15,140.46	2.59%	train				
Remote	High	1,522,611.48	36	4	38,460.04	2.53%	train				
Remote	Low	1,234,685.15	19	4	35,242.68	2.85%	train				
Local	Low	982,920.06	21	3	19,533.59	1.99%	train				
Local	Medium	1,788,200.40	12	4	63,977.84	3.58%	train				
Local	High	1,082,133.01	21	4	29,080.18	2.69%	test	28,236.53	Good	843.65	2.90%
Remote	High	1,035,386.38	25	4	30,371.33	2.93%	test	31,220.71	Good	-849.38	-2.80%
Remote	Medium	1,264,034.73	14	3	42,736.41	3.38%	train				
Remote	High	1,367,409.84	19	4	45,868.20	3.35%	train				
Remote	Low	1,002,553.31	13	5	37,737.13	3.76%	train				
Local	Low	1,420,828.51	19	3	29,189.30	2.05%	train				
Local	Low	1,709,337.52	15	4	48,241.30	2.82%	train				
Local	High	609,335.11	28	4	14,566.01	2.39%	test	14,651.91	Good	-85.90	-0.59%
Remote	High	833,883.05	30	4	23,441.38	2.81%	train				

LOCATION	COMPLEXITY	BUDGET	DURATION	RELEVANT STAKEHOLDER GROUPS	PM COST	% PM COST	TAG USED	TEST	GOOD OR BAD	RESIDUAL	%
Remote	Low	1,297,801.29	23	3	29,191.12	2.25%	train				
Remote	Low	1,119,369.76	14	3	35,606.62	3.18%	train				
Local	Low	925,628.02	19	4	22,718.48	2.45%	train				
Local	High	667,414.59	24	3	15,276.38	2.29%	train				
Remote	High	1,722,870.56	19	5	59,514.60	3.45%	train				
Local	Low	951,195.05	23	5	21,395.00	2.25%	test	20,650.89	Good	744.11	3.48%
Local	Low	1,363,830.91	18	5	34,802.94	2.55%	train				
Remote	Medium	1,151,990.74	24	4	30,975.75	2.69%	train				
Local	High	1,125,818.31	30	5	26,018.91	2.31%	train				
Remote	High	1,279,302.89	28	3	31,860.73	2.49%	train				
Local	Medium	555,745.83	16	3	14,912.51	2.68%	test	17,164.08	Good	-2,251.57	-15.10%
Local	High	1,437,619.16	15	5	49,198.52	3.42%	train				
Remote	Low	512,839.97	15	3	16,012.00	3.12%	train				
Remote	Low	1,108,388.88	18	3	29,392.83	2.65%	train				
Local	Low	1,491,757.71	14	4	44,468.59	2.98%	train				
Local	High	573,367.88	25	4	14,525.32	2.53%	train				
Local	High	577,732.27	28	5	14,388.28	2.49%	test	13,498.17	Good	890.11	6.19%
Remote	Low	1,340,923.44	30	3	25,626.54	1.91%	train				
Local	Medium	1,218,034.19	30	3	19,623.88	1.61%	train				
Remote	Medium	982,929.62	15	4	35,603.90	3.62%	train				
Remote	Low	918,511.12	15	3	28,677.96	3.12%	train				
Remote	High	799,134.56	34	3	19,022.54	2.38%	train				
Local	Medium	1,699,228.84	14	4	54,051.66	3.18%	train				
Local	Medium	557,737.83	20	4	14,315.27	2.57%	train				
Local	Medium	1,308,696.78	25	4	27,918.86	2.13%	train				
Local	Low	823,502.63	21	3	16,365.48	1.99%	train				
Local	Low	1,277,239.09	22	5	28,292.78	2.22%	train				
Remote	High	951,405.82	17	3	31,974.70	3.36%	train				
Remote	Low	615,510.45	19	5	18,800.06	3.05%	train				
Local	Low	852,551.98	24	3	15,251.21	1.79%	test	16,513.71	Good	-1,262.50	-8.28%
Local	Low	514,229.05	22	5	11,905.18	2.32%	train				
Local	Medium	831,541.04	19	4	22,072.31	2.65%	train				
Local	Medium	1,035,118.41	21	4	24,711.40	2.39%	train				
Remote	High	813,527.00	16	4	30,778.44	3.78%	test	31,776.14	Good	-997.71	-3.24%
Local	Low	534,936.99	27	5	10,883.66	2.03%	test	11,947.44	Good	-1,063.79	-9.77%
Remote	High	839,992.75	27	3	22,130.18	2.63%	test	21,463.60	Good	666.58	3.01%
Local	High	968,941.49	20	4	27,776.32	2.87%	train				
Local	High	1,455,430.69	23	3	32,736.64	2.25%	train				
Remote	Low	553,402.62	20	4	15,864.21	2.87%	train				
Remote	Low	1,550,217.54	15	3	46,851.02	3.02%	train				
Remote	Medium	1,571,769.84	20	3	41,913.86	2.67%	train				
Local	Low	958,266.50	21	4	21,918.44	2.29%	train				

LOCA-TION	COMPLE-XITY	BUDGET	DURA-TION	RELE-VANT STAKE-HOLDER GROUPS	PM COST	% PM COST	TAG USED	TEST	GOOD OR BAD	RESIDUAL	%
Remote	High	1,203,129.39	12	5	53,873.46	4.48%	train				
Local	Medium	512,774.70	19	4	13,611.02	2.65%	train				
Remote	Low	1,572,775.22	24	3	34,426.30	2.19%	train				
Local	High	928,720.44	21	3	23,100.08	2.49%	test	22,313.20	Good	786.88	3.41%
Local	Low	1,286,047.40	13	5	41,977.91	3.26%	test	43,382.91	Good	-1,405.01	-3.35%
Local	Medium	897,200.07	21	3	19,624.47	2.19%	train				
Local	Medium	506,773.64	28	3	9,073.66	1.79%	test	10,009.00	Good	-935.33	-10.31%
Remote	Medium	1,561,191.51	16	5	54,381.50	3.48%	test	53,120.34	Good	1,261.17	2.32%
Local	High	903,316.02	20	4	25,895.06	2.87%	train				
Remote	Medium	580,211.77	20	3	16,052.53	2.77%	test	17,675.50	Good	-1,622.97	-10.11%
Remote	Low	595,520.47	15	5	20,975.55	3.52%	train				
Local	Low	1,001,793.43	19	4	23,586.08	2.35%	test	21,799.23	Good	1,786.85	7.58%
Local	Low	655,421.89	16	5	18,898.00	2.88%	train				
Local	High	897,256.60	20	4	25,721.36	2.87%	train				
Remote	Low	604,357.31	19	3	16,041.98	2.65%	train				
Remote	High	868,980.86	18	4	30,864.91	3.55%	train				
Local	Medium	1,054,258.00	16	3	27,235.00	2.58%	train				
Local	Low	504,023.79	19	3	10,858.62	2.15%	train				
Remote	Medium	984,726.14	26	3	23,456.68	2.38%	train				
Remote	Low	914,671.35	20	3	23,476.56	2.57%	test	23,342.33	Good	134.24	0.57%
Local	Low	816,984.05	33	3	11,520.30	1.41%	train				
Local	Medium	1,102,518.04	15	5	34,423.06	3.12%	test	32,270.39	Good	2,152.67	6.25%
Local	Medium	1,568,418.96	18	3	36,886.89	2.35%	train				
Local	Low	866,386.50	27	4	16,760.84	1.93%	train				
Remote	Low	945,814.91	19	3	25,105.58	2.65%	train				
Remote	Medium	1,352,496.54	25	4	35,615.74	2.63%	train				
Remote	Low	1,007,543.31	21	3	24,053.10	2.39%	train				
Local	Medium	1,585,230.00	17	4	43,764.78	2.76%	train				
Remote	High	599,627.37	28	3	15,533.20	2.59%	test	15,007.94	Good	525.27	3.38%
Local	Medium	1,063,937.52	33	3	16,066.53	1.51%	test	19,098.46	Good	-3,031.93	-18.87%
Remote	Low	1,316,509.72	17	3	36,345.99	2.76%	train				
Local	Low	819,992.37	36	5	14,152.46	1.73%	train				
Remote	Medium	1,059,271.62	15	3	34,132.09	3.22%	test	34,598.62	Good	-466.54	-1.37%
Remote	High	661,598.27	36	3	15,388.29	2.33%	train				
Local	Low	556,860.84	22	3	10,664.73	1.92%	train				
Remote	High	1,629,259.58	20	4	53,222.48	3.27%	train				
Local	Medium	560,885.36	27	5	12,533.36	2.23%	train				
Remote	Low	1,128,949.92	36	3	19,484.84	1.73%	train				
Remote	Low	1,140,022.19	16	3	32,870.64	2.88%	train				
Local	Medium	1,277,998.06	23	5	30,023.69	2.35%	test	29,794.51	Good	229.18	0.76%
Local	Low	1,370,381.07	13	4	43,360.26	3.16%	train				
Remote	Medium	622,821.80	20	3	17,231.40	2.77%	train				

LOCA-TION	COMPLE-XITY	BUDGET	DURA-TION	RELE-VANT STAKE-HOLDER GROUPS	PM COST	% PM COST	TAG USED	TEST	GOOD OR BAD	RESIDUAL	%
Local	Low	606,852.57	26	5	12,634.98	2.08%	train				
Remote	Low	951,616.00	12	5	38,804.79	4.08%	train				
Remote	Medium	617,490.46	35	3	12,673.26	2.05%	train				
Local	Low	704,413.02	34	3	9,723.66	1.38%	test	9,729.60	Good	-5.94	-0.06%
Remote	Low	580,202.08	32	3	11,265.59	1.94%	train				
Local	Low	1,283,482.92	30	5	23,245.30	1.81%	train				
Remote	Low	1,615,066.28	23	4	41,172.49	2.55%	test	38,529.89	Good	2,642.60	6.42%
Remote	Medium	1,221,684.39	25	3	28,505.97	2.33%	train				
Local	Low	1,554,072.32	21	4	33,992.25	2.19%	test	32,400.12	Good	1,592.13	4.68%
Local	Medium	1,147,660.40	21	3	23,955.13	2.09%	test	25,670.99	Good	-1,715.86	-7.16%
Remote	Low	1,226,103.02	27	3	24,945.90	2.03%	train				
Remote	Low	514,184.61	22	3	12,418.34	2.42%	train				
Remote	Medium	1,559,320.98	22	3	39,219.29	2.52%	train				
Remote	Medium	904,655.73	18	3	26,704.10	2.95%	train				
Remote	Low	1,304,661.29	22	4	34,118.87	2.62%	test	32,420.45	Good	1,698.42	4.98%
Remote	Medium	573,409.51	16	4	19,973.76	3.48%	train				
Remote	High	545,633.58	21	3	16,299.72	2.99%	train				
Remote	High	503,090.27	33	4	13,634.25	2.71%	train				
Local	Medium	525,195.05	30	5	11,087.45	2.11%	train				
Local	Low	894,012.12	17	5	24,681.75	2.76%	train				
Local	Medium	833,563.20	22	3	17,631.12	2.12%	train				
Local	Low	535,711.70	22	4	11,866.83	2.22%	train				
Local	Medium	1,325,009.13	24	4	29,002.98	2.19%	train				
Remote	Medium	590,318.95	22	5	17,799.01	3.02%	train				
Local	High	1,770,395.16	22	3	40,987.33	2.32%	train				
Local	High	1,405,512.56	16	3	40,525.61	2.88%	train				
Local	Medium	1,286,163.78	17	3	31,649.72	2.46%	train				
Local	Low	1,103,463.05	15	3	27,831.79	2.52%	train				
Remote	Medium	885,202.32	20	4	27,146.20	3.07%	test	25,689.17	Good	1,457.04	5.37%
Local	Low	1,220,977.54	27	4	22,399.66	1.83%	train				
Remote	High	679,641.98	31	3	16,822.97	2.48%	train				
Local	Medium	1,158,479.42	20	5	29,734.31	2.57%	train				
Remote	High	1,297,008.10	16	3	43,882.11	3.38%	train				
Local	Medium	595,980.69	31	3	9,984.28	1.68%	train				
Remote	Low	812,827.47	19	3	21,575.58	2.65%	train				
Remote	Low	800,720.74	20	4	22,953.99	2.87%	train				
Local	Low	1,360,528.32	31	4	22,792.51	1.68%	test	22,768.65	Good	23.86	0.10%
Remote	Medium	622,078.94	25	3	15,137.25	2.43%	train				
Local	Medium	1,048,802.19	22	4	24,281.36	2.32%	test	25,044.15	Good	-762.79	-3.14%
Local	High	964,150.49	20	4	27,638.98	2.87%	train				
Remote	Low	1,270,776.17	21	4	34,149.59	2.69%	train				
Local	Medium	1,236,912.47	26	5	26,990.06	2.18%	test	27,084.03	Good	-93.96	-0.35%

LOCA-TION	COMPLE-XITY	BUDGET	DURA-TION	RELE-VANT STAKE-HOLDER GROUPS	PM COST	% PM COST	TAG USED	TEST	GOOD OR BAD	RESIDUAL	%
Local	Medium	828,706.86	16	4	24,723.09	2.98%	train				
Remote	High	946,925.63	15	3	34,299.75	3.62%	train				
Local	Medium	826,666.64	20	5	22,044.44	2.67%	train				
Local	Medium	744,008.05	22	4	17,968.92	2.42%	train				
Local	Medium	1,335,476.56	18	3	31,408.43	2.35%	train				
Remote	Low	540,059.74	12	3	19,862.20	3.68%	train				
Remote	Medium	1,937,816.91	19	3	53,374.96	2.75%	train				
Remote	Medium	769,785.60	17	3	23,561.48	3.06%	train				
Local	Medium	1,094,632.16	20	4	27,000.93	2.47%	train				
Remote	High	1,280,061.70	22	3	36,035.68	2.82%	train				
Remote	High	896,347.09	36	4	23,537.41	2.63%	train				
Local	Low	704,793.42	16	3	17,502.37	2.48%	train				
Remote	High	849,940.50	21	4	27,940.11	3.29%	train				
Local	Low	1,325,031.76	28	4	23,724.38	1.79%	train				
Remote	Medium	1,493,825.11	21	5	44,625.06	2.99%	train				
Remote	Low	640,849.31	33	3	12,240.87	1.91%	test	11,703.26	Good	537.61	4.39%
Remote	Medium	536,908.21	19	3	15,325.43	2.85%	train				
Remote	Low	1,167,617.40	16	4	37,169.15	3.18%	train				
Local	High	1,192,348.18	26	3	24,825.30	2.08%	train				
Remote	Low	531,703.85	15	3	16,600.98	3.12%	test	17,783.95	Good	-1,182.98	-7.13%
Remote	Medium	1,510,277.92	19	3	41,598.88	2.75%	train				
Local	Medium	1,438,409.49	35	3	20,891.19	1.45%	test	19,508.51	Good	1,382.68	6.62%
Remote	Medium	866,217.66	17	5	29,977.92	3.46%	train				
Local	High	1,830,390.71	28	4	37,189.23	2.03%	train				
Remote	Medium	993,322.40	12	4	41,498.80	4.18%	train				
Local	Low	948,143.98	15	3	24,862.44	2.62%	train				
Local	Medium	1,379,684.09	21	4	32,937.22	2.39%	train				
Remote	Low	1,120,685.21	14	5	40,131.20	3.58%	test	38,958.02	Good	1,173.18	2.92%
Local	Medium	1,163,330.12	19	4	29,715.94	2.55%	train				
Local	Medium	1,028,805.86	21	3	21,474.28	2.09%	train				
Local	Medium	698,116.99	19	3	16,436.37	2.35%	train				
Local	Medium	520,721.77	21	3	11,389.76	2.19%	train				
Remote	Medium	1,761,126.50	20	5	54,007.88	3.07%	train				
Remote	High	1,657,808.50	31	4	44,350.83	2.68%	test	46,338.40	Good	-1,987.57	-4.48%
Local	Medium	1,458,640.17	25	4	31,117.66	2.13%	train				
Remote	High	1,143,918.74	19	3	34,939.69	3.05%	train				
Remote	Low	539,042.04	24	5	14,494.24	2.69%	test	16,519.13	Good	-2,024.88	-13.97%
Local	Medium	809,443.86	15	5	26,082.08	3.22%	train				
Local	High	1,767,884.50	25	3	37,714.87	2.13%	train				
Local	High	771,280.77	21	3	19,184.08	2.49%	train				
Remote	Low	625,360.95	26	5	16,147.14	2.58%	train				
Remote	Low	599,119.11	15	5	21,102.31	3.52%	train				

LOCA-TION	COMPLE-XITY	BUDGET	DURA-TION	RELE-VANT STAKE-HOLDER GROUPS	PM COST	% PM COST	TAG USED	TEST	GOOD OR BAD	RESIDUAL	%
Local	High	854,967.79	22	3	20,648.77	2.42%	train				
Local	Low	614,910.44	18	4	15,691.60	2.55%	train				
Local	High	1,010,812.89	16	3	29,145.11	2.88%	train				
Local	Low	1,605,359.49	15	3	40,490.73	2.52%	train				
Local	Low	909,185.58	25	5	19,395.96	2.13%	train				
Remote	Medium	559,258.89	15	3	18,579.82	3.32%	train				
Remote	High	575,367.10	20	4	19,370.69	3.37%	test	18,927.68	Good	443.01	2.29%
Remote	Medium	565,256.88	30	5	14,759.49	2.61%	train				
Local	Medium	868,794.53	20	3	19,692.68	2.27%	test	19,750.18	Good	-57.50	-0.29%
Local	Medium	513,426.44	24	3	10,211.48	1.99%	train				
Local	Medium	565,225.63	33	3	9,100.70	1.61%	train				
Remote	Low	1,750,698.16	16	5	57,481.26	3.28%	train				
Remote	Low	777,901.92	18	3	21,406.71	2.75%	train				
Local	Low	1,485,078.05	32	4	24,380.03	1.64%	test	25,014.55	Good	-634.52	-2.60%
Local	High	785,613.65	34	3	14,772.62	1.88%	train				
Local	Low	706,311.75	19	3	15,216.68	2.15%	train				
Remote	Low	739,540.41	21	5	21,352.76	2.89%	train				
Remote	High	1,342,549.88	20	3	39,828.98	2.97%	train				
Local	High	1,201,962.84	21	3	28,694.48	2.39%	train				
Remote	High	735,242.88	17	3	24,709.93	3.36%	test	24,688.38	Good	21.55	0.09%
Remote	High	1,712,608.43	16	3	57,943.25	3.38%	train				
Local	High	1,050,306.81	16	4	33,434.77	3.18%	train				
Remote	Medium	538,418.45	28	4	13,947.60	2.59%	train				
Local	Medium	606,669.12	32	5	12,386.16	2.04%	train				
Local	Low	888,601.69	20	3	18,364.43	2.07%	train				
Local	High	602,631.37	25	3	13,458.77	2.23%	train				
Local	Medium	528,769.94	28	5	11,582.58	2.19%	train				
Remote	Medium	733,381.20	24	5	21,186.57	2.89%	test	19,471.21	Good	1,715.35	8.10%
Remote	Low	615,606.68	31	5	14,622.31	2.38%	train				
Local	Low	1,038,350.37	30	3	14,652.28	1.41%	train				
Remote	Low	1,008,605.83	15	3	30,482.31	3.02%	train				
Remote	Medium	1,537,920.89	23	4	42,281.68	2.75%	train				
Remote	Medium	1,246,255.59	14	4	45,874.07	3.68%	train				
Remote	Medium	563,905.89	21	4	16,845.57	2.99%	train				
Local	High	1,033,174.25	18	4	30,497.77	2.95%	test	28,677.64	Good	1,820.13	5.97%
Remote	Low	658,752.67	20	3	16,907.99	2.57%	train				
Remote	Medium	829,602.26	20	3	22,952.33	2.77%	train				
Local	Medium	1,771,365.49	16	5	52,845.74	2.98%	train				
Remote	Medium	511,380.29	22	4	14,907.51	2.92%	test	17,273.01	Good	-2,365.50	-15.87%
Local	Medium	1,543,534.66	20	3	33,443.25	2.17%	train				
Remote	Medium	629,687.82	27	3	14,700.49	2.33%	train				
Remote	Medium	895,421.00	25	4	24,474.84	2.73%	train				

LOCA-TION	COMPLE-XITY	BUDGET	DURA-TION	RELE-VANT STAKE-HOLDER GROUPS	PM COST	% PM COST	TAG USED	TEST	GOOD OR BAD	RESIDUAL	%
Remote	Low	556,260.00	14	4	19,919.41	3.58%	test	20,022.91	Good	-103.50	-0.52%
Local	Medium	1,817,837.94	27	3	31,531.63	1.73%	train				
Local	Medium	1,622,698.23	20	4	40,026.56	2.47%	test	38,438.01	Good	1,588.54	3.97%
Remote	Medium	846,257.51	27	3	19,756.46	2.33%	train				
Local	Medium	1,611,292.85	16	3	41,625.07	2.58%	train				
Remote	Low	1,262,421.26	18	5	38,527.23	3.05%	test	37,941.67	Good	585.56	1.52%
Remote	Medium	612,061.28	36	3	12,399.91	2.03%	train				
Remote	High	1,129,246.13	12	3	46,048.15	4.08%	train				
Local	Low	537,807.95	25	4	10,935.43	2.03%	train				
Local	Low	955,684.84	26	3	16,075.11	1.68%	train				
Remote	High	1,134,051.12	25	4	33,265.50	2.93%	train				
Remote	Medium	600,240.51	19	4	18,933.90	3.15%	train				
Remote	Low	995,130.04	27	3	21,241.73	2.13%	train				
Remote	Low	1,141,834.26	19	3	29,166.85	2.55%	train				
Remote	Medium	950,139.68	16	3	30,246.11	3.18%	train				
Remote	High	1,236,433.40	12	3	50,419.01	4.08%	train				
Local	Low	1,149,263.50	28	5	21,726.55	1.89%	test	22,898.96	Good	-1,172.40	-5.40%
Local	High	697,640.20	21	3	17,352.42	2.49%	train				
Remote	Medium	584,742.74	26	3	13,928.87	2.38%	train				
Local	High	1,439,365.41	15	3	43,500.82	3.02%	train				
Local	High	644,115.39	35	5	14,507.93	2.25%	train				
Remote	Low	875,107.31	19	3	23,228.73	2.65%	train				
Local	Low	1,471,608.90	30	5	26,652.47	1.81%	train				
Local	Medium	630,681.97	21	5	16,317.64	2.59%	train				
Local	Low	1,134,830.22	15	3	28,622.94	2.52%	test	27,401.45	Good	1,221.49	4.27%
Local	Low	1,515,009.77	24	3	25,586.83	1.69%	train				
Local	Medium	503,379.10	24	4	11,521.79	2.29%	train				
Local	Medium	1,289,329.63	13	5	44,663.70	3.46%	train				
Remote	Low	540,092.44	20	3	13,862.37	2.57%	train				
Remote	Medium	1,506,018.23	27	3	33,653.00	2.23%	test	36,646.12	Good	-2,993.12	-8.89%
Local	Low	1,223,357.49	20	3	24,059.36	1.97%	train				
Remote	Low	1,177,260.33	22	3	27,255.36	2.32%	train				
Remote	Low	567,631.63	20	3	14,569.21	2.57%	train				
Remote	Low	1,059,977.22	30	3	20,257.34	1.91%	train				
Remote	High	1,426,212.38	33	3	32,946.95	2.31%	train				
Remote	Low	1,078,018.55	34	5	23,505.03	2.18%	test	20,705.97	Good	2,799.07	11.91%
Local	Medium	1,642,148.81	23	4	36,936.45	2.25%	train				
Remote	Medium	568,875.01	27	3	13,280.77	2.33%	train				
Local	Medium	1,323,716.42	12	5	48,683.35	3.68%	test	45,392.41	Good	3,290.94	6.76%
Remote	Low	1,242,074.92	22	3	28,755.92	2.32%	train				
Remote	Low	533,466.84	19	5	16,294.14	3.05%	train				
Remote	High	1,341,511.76	20	5	45,164.23	3.37%	train				

LOCATION	COMPLEXITY	BUDGET	DURATION	RELEVANT STAKEHOLDER GROUPS	PM COST	% PM COST	TAG USED	TEST	GOOD OR BAD	RESIDUAL	%
Remote	Medium	1,190,106.86	17	3	35,236.50	2.96%	train				
Remote	Medium	1,639,194.71	12	4	66,842.72	4.08%	train				
Local	High	557,365.65	17	4	17,617.13	3.16%	train				
Remote	Low	840,319.07	15	4	28,757.59	3.42%	test	29,966.92	Good	-1,209.33	-4.21%
Local	Low	575,092.91	30	3	8,690.29	1.51%	train				
Local	Medium	865,197.22	19	3	20,370.08	2.35%	train				
Local	Low	1,283,649.31	21	4	28,077.28	2.19%	train				
Local	High	1,127,308.76	21	4	30,294.19	2.69%	train				
Remote	Low	863,172.40	15	5	30,402.85	3.52%	train				
Local	Medium	822,039.76	24	4	18,815.58	2.29%	train				
Remote	Low	562,812.48	15	4	19,260.69	3.42%	train				
Local	Low	502,502.19	24	4	10,496.71	2.09%	test	11,330.66	Good	-833.95	-7.94%
Remote	Low	518,239.43	34	5	11,817.89	2.28%	train				
Local	High	1,282,007.44	15	4	42,591.14	3.32%	train				
Remote	Medium	774,354.55	35	3	15,892.71	2.05%	train				
Remote	Low	589,499.15	21	4	16,431.12	2.79%	test	16,242.83	Good	188.28	1.15%
Remote	Medium	1,682,541.00	24	3	40,194.04	2.39%	train				
Local	Medium	838,064.15	24	3	16,668.16	1.99%	test	18,249.56	Good	-1,581.39	-9.49%
Remote	Medium	1,197,097.75	15	3	38,573.15	3.22%	train				
Local	Low	673,022.37	15	3	17,648.14	2.62%	train				
Local	Medium	989,563.79	14	4	32,467.12	3.28%	train				
Local	Low	1,314,990.27	26	3	20,803.82	1.58%	test	21,387.48	Good	-583.66	-2.81%
Local	High	1,768,637.41	33	5	39,088.67	2.21%	train				
Remote	Medium	902,133.76	34	3	18,767.92	2.08%	train				
Remote	Medium	768,791.62	21	4	22,966.12	2.99%	train				
Local	Medium	834,143.17	21	3	18,245.23	2.19%	train				
Local	Low	1,721,279.85	20	3	33,851.84	1.97%	train				
Remote	Medium	649,359.38	28	4	16,821.50	2.59%	test	14,796.02	Good	2,025.48	12.04%
Remote	Medium	1,292,141.59	30	5	32,447.11	2.51%	train				
Local	Medium	1,162,828.90	31	3	18,317.68	1.58%	test	19,475.00	Good	-1,157.31	-6.32%
Remote	Low	522,425.32	24	3	11,957.74	2.29%	test	13,711.25	Good	-1,753.51	-14.66%
Remote	Low	1,259,321.65	18	5	38,432.63	3.05%	train				
Local	High	753,129.64	34	3	14,161.79	1.88%	test	14,469.25	Good	-307.46	-2.17%
Local	High	1,591,469.31	13	4	58,313.07	3.66%	train				
Local	High	1,815,026.04	15	5	62,114.22	3.42%	train				
Remote	Medium	539,535.55	16	4	18,793.82	3.48%	test	19,527.43	Good	-733.61	-3.90%
Remote	Medium	1,012,917.15	17	3	29,990.29	2.96%	train				
Local	Low	1,191,074.21	24	3	20,115.92	1.69%	train				
Remote	Medium	1,242,927.66	25	3	29,001.65	2.33%	train				
Local	Low	866,382.17	26	3	14,572.99	1.68%	train				
Remote	High	1,809,778.83	14	3	66,617.10	3.68%	train				
Local	Low	1,200,895.52	19	4	28,273.72	2.35%	train				

LOCA-TION	COMPLE-XITY	BUDGET	DURA-TION	RELE-VANT STAKE-HOLDER GROUPS	PM COST	% PM COST	TAG USED	TEST	GOOD OR BAD	RESIDUAL	%
Remote	High	664,897.90	21	3	19,862.51	2.99%	train				
Remote	Low	838,060.77	19	3	22,245.37	2.65%	test	22,111.30	Good	134.06	0.60%
Local	High	708,604.12	15	3	22,124.20	3.12%	train				
Remote	High	721,495.49	21	5	24,439.23	3.39%	test	22,337.15	Good	2,102.08	8.60%
Local	Medium	1,455,977.09	15	3	39,634.93	2.72%	train				
Local	Low	1,111,810.02	27	3	17,061.48	1.53%	test	17,956.39	Good	-894.91	-5.25%
Remote	Low	1,587,492.55	16	5	52,122.67	3.28%	train				
Local	Low	879,426.14	20	3	18,174.81	2.07%	train				
Remote	Low	814,569.24	24	3	18,644.58	2.29%	train				
Remote	Low	550,677.71	29	3	11,285.73	2.05%	train				
Remote	Low	654,244.47	28	3	13,676.82	2.09%	train				
Local	Medium	1,142,844.15	19	5	30,335.49	2.65%	train				
Local	Medium	873,476.34	21	3	19,105.56	2.19%	train				
Remote	Medium	554,435.96	13	3	20,315.10	3.66%	train				
Local	Medium	825,566.09	15	4	25,776.01	3.12%	train				
Remote	Low	633,649.59	26	3	13,826.56	2.18%	train				
Remote	High	587,307.33	20	4	19,772.68	3.37%	train				
Remote	Low	641,383.96	35	3	11,880.87	1.85%	train				
Remote	Medium	1,481,728.02	17	3	43,870.77	2.96%	test	42,949.19	Good	921.58	2.10%
Local	Medium	1,007,413.35	34	5	18,943.32	1.88%	train				
Local	Medium	643,538.40	26	5	14,685.88	2.28%	train				
Remote	Low	1,827,161.32	16	3	52,683.15	2.88%	train				
Remote	Low	964,830.02	15	4	33,018.63	3.42%	train				
Local	Low	632,906.70	22	3	12,121.12	1.92%	train				
Local	Low	526,027.21	34	3	7,261.24	1.38%	train				
Remote	Medium	731,439.19	20	3	20,236.48	2.77%	train				
Local	Low	886,535.29	20	3	18,321.73	2.07%	train				
Remote	Medium	1,055,346.94	20	4	31,308.63	2.97%	test	31,889.28	Good	-580.66	-1.85%
Local	Low	1,248,941.20	33	3	16,362.39	1.31%	train				
Local	High	618,518.54	21	3	15,384.42	2.49%	train				
Local	Low	530,522.61	15	3	13,911.48	2.62%	train				
Local	Low	1,009,146.22	22	4	21,344.97	2.12%	train				
Local	High	1,021,674.63	27	3	20,786.66	2.03%	train				
Remote	Low	1,121,376.46	22	5	30,447.07	2.72%	train				
Local	Low	638,464.57	31	4	11,334.46	1.78%	train				
Remote	Medium	1,256,833.06	34	3	24,890.22	1.98%	train				
Remote	High	546,298.17	30	4	15,357.05	2.81%	train				
Local	Medium	987,396.42	15	3	27,866.52	2.82%	test	26,778.88	Good	1,087.64	3.90%
Remote	Medium	1,046,307.06	21	5	31,256.35	2.99%	train				
Local	High	694,023.76	29	4	16,305.57	2.35%	train				
Local	Medium	1,234,868.04	27	5	26,359.10	2.13%	train				
Local	Medium	632,587.31	24	3	12,581.46	1.99%	train				

LOCA-TION	COMPLE-XITY	BUDGET	DURA-TION	RELE-VANT STAKE-HOLDER GROUPS	PM COST	% PM COST	TAG USED	TEST	GOOD OR BAD	RESIDUAL	%
Remote	High	1,366,884.27	21	4	43,566.72	3.19%	train				
Remote	Medium	869,516.65	12	3	33,717.92	3.88%	test	34,888.20	Good	-1,170.28	-3.47%
Remote	High	924,774.23	20	4	31,134.07	3.37%	train				
Remote	High	1,729,408.45	21	3	49,933.24	2.89%	train				
Local	Low	1,633,982.66	35	4	25,365.64	1.55%	train				
Local	Medium	814,029.10	15	4	25,415.80	3.12%	train				
Local	High	994,502.93	21	3	24,736.29	2.49%	test	24,108.59	Good	627.70	2.54%
Remote	Low	573,443.71	23	3	13,471.77	2.35%	train				
Local	Medium	586,644.29	30	5	12,384.71	2.11%	test	12,332.61	Good	52.10	0.42%
Local	Low	1,194,191.56	20	3	23,485.77	1.97%	train				
Local	Low	640,851.46	29	4	11,852.07	1.85%	train				
Local	High	653,026.72	15	3	20,388.95	3.12%	train				
Remote	Low	1,123,457.64	30	3	21,470.52	1.91%	train				
Remote	Medium	807,182.36	23	3	20,577.30	2.55%	train				
Remote	Low	1,367,692.12	17	4	41,862.11	3.06%	train				
Local	Low	573,685.93	27	4	11,098.34	1.93%	train				
Local	Medium	567,217.09	20	3	12,856.92	2.27%	train				
Remote	Medium	1,188,181.44	21	4	34,306.38	2.89%	train				
Local	Medium	552,218.25	12	3	18,652.71	3.38%	train				
Local	Medium	575,508.83	19	5	15,851.73	2.75%	train				
Local	Low	1,022,032.17	16	3	24,358.43	2.38%	test	24,273.38	Good	85.06	0.35%
Remote	High	1,245,112.01	17	3	40,600.42	3.26%	train				
Local	Medium	764,762.97	35	3	11,872.03	1.55%	test	12,294.49	Good	-422.46	-3.56%
Remote	High	534,546.78	16	4	20,223.69	3.78%	train				
Local	Medium	934,959.92	19	5	25,752.40	2.75%	train				
Local	High	1,680,626.26	17	5	53,120.97	3.16%	train				
Local	Medium	1,072,671.58	24	4	23,479.59	2.19%	train				
Remote	High	1,556,942.09	17	3	50,768.52	3.26%	test	52,653.72	Good	-1,885.20	-3.71%
Local	Low	1,368,257.92	16	4	36,714.92	2.68%	train				
Remote	Low	551,086.24	20	3	14,144.55	2.57%	train				
Local	Medium	860,268.78	25	5	20,072.94	2.33%	train				
Local	High	584,003.61	16	4	19,174.79	3.28%	train				
Remote	Low	625,248.12	18	3	17,205.90	2.75%	train				
Local	Low	1,689,416.73	30	4	28,907.80	1.71%	test	26,945.85	Good	1,961.94	6.79%
Remote	Medium	1,069,349.15	15	5	38,734.20	3.62%	train				
Remote	Low	627,751.93	15	4	21,483.07	3.42%	test	20,197.79	Good	1,285.28	5.98%
Local	High	1,268,675.38	20	4	35,100.02	2.77%	train				
Local	High	1,547,340.00	27	5	37,671.04	2.43%	train				
Local	Medium	1,294,799.07	20	4	31,938.38	2.47%	train				
Remote	High	1,185,245.00	32	4	31,310.22	2.64%	test	28,602.72	Good	2,707.50	8.65%
Local	Low	524,430.06	33	3	7,394.99	1.41%	train				
Local	Medium	663,249.69	28	5	14,528.33	2.19%	train				

LOCA-TION	COMPLE-XITY	BUDGET	DURA-TION	RELE-VANT STAKE-HOLDER GROUPS	PM COST	% PM COST	TAG USED	TEST	GOOD OR BAD	RESIDUAL	%
Local	Medium	1,653,133.09	15	4	49,961.36	3.02%	train				
Local	Medium	528,820.61	20	4	13,573.06	2.57%	train				
Local	Medium	519,719.13	30	3	8,892.97	1.71%	train				
Remote	Medium	743,037.32	33	5	18,650.99	2.51%	train				
Remote	Medium	856,258.79	24	3	21,311.33	2.49%	test	21,521.34	Good	-210.01	-0.99%
Local	High	620,702.06	31	4	14,122.64	2.28%	train				
Remote	Medium	1,284,054.66	24	4	34,526.80	2.69%	test	33,189.13	Good	1,337.68	3.87%
Remote	Low	1,221,724.86	15	5	41,810.14	3.42%	train				
Local	Low	1,713,664.43	16	4	45,983.33	2.68%	train				
Remote	Medium	1,277,241.72	36	3	24,598.73	1.93%	test	25,616.68	Good	-1,017.95	-4.14%
Remote	Medium	1,376,535.12	15	3	44,355.02	3.22%	train				
Local	Medium	1,201,960.23	30	3	19,364.91	1.61%	train				
Local	Medium	1,048,096.64	16	4	30,220.12	2.88%	train				
Local	Medium	781,372.88	16	3	20,966.84	2.68%	train				
Local	Low	889,253.80	16	4	24,750.90	2.78%	test	22,245.27	Good	2,505.62	10.12%
Remote	Low	635,992.33	32	5	14,892.82	2.34%	test	13,943.56	Good	949.26	6.37%
Local	Low	510,489.36	31	4	9,062.56	1.78%	train				
Local	Medium	880,766.98	15	3	24,857.20	2.82%	train				
Remote	Medium	843,268.82	20	3	23,330.44	2.77%	test	23,204.29	Good	126.15	0.54%
Local	High	1,296,821.96	23	5	34,356.38	2.65%	train				
Local	Medium	1,484,991.68	14	5	48,721.87	3.28%	train				
Local	Medium	1,273,825.30	24	3	24,061.14	1.89%	train				
Local	Low	1,066,325.50	20	3	20,971.07	1.97%	train				
Remote	Low	941,441.39	16	5	31,852.10	3.38%	train				
Local	Low	546,951.49	23	3	10,114.64	1.85%	train				
Remote	Low	661,069.81	20	4	18,950.67	2.87%	train				
Local	Medium	568,661.89	20	4	14,595.66	2.57%	train				
Remote	Low	1,240,392.01	16	3	35,764.64	2.88%	train				
Remote	Medium	1,474,071.34	34	4	33,614.61	2.28%	train				
Remote	High	504,448.03	31	3	12,486.44	2.48%	train				
Remote	Low	869,608.71	23	4	23,038.33	2.65%	train				
Remote	Medium	1,484,723.62	20	4	44,046.80	2.97%	train				
Remote	Low	568,098.78	22	3	13,720.45	2.42%	train				
Remote	High	809,584.87	21	5	27,423.08	3.39%	test	28,005.36	Good	-582.28	-2.12%
Remote	Medium	1,283,825.59	19	5	40,496.81	3.15%	train				
Remote	Low	568,442.98	34	3	10,688.96	1.88%	test	11,691.38	Good	-1,002.42	-9.38%
Local	Medium	543,071.16	17	5	16,079.17	2.96%	train				
Remote	Medium	1,206,922.14	20	3	32,184.59	2.67%	train				
Local	Low	1,565,873.75	23	5	33,654.94	2.15%	train				
Remote	Low	686,957.91	19	3	18,234.51	2.65%	train				

RICARDO VARGAS

IDENTIFYING AND RECOVERING TROUBLED PROJECTS: HOW TO RESCUE YOUR PROJECT FROM ITS FAILURE

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Hong Kong – China – 2007

Mundo PM Magazine
Curitiba – PR – Brazil – 2006

Abstract

Related Podcasts

♫ Understanding the Early Closure of a Project
http://rvarg.as/b1

♫ Recovery Strategies for Troubled Projects *(audio in Portuguese)*
http://rvarg.as/bl

♫ Troubled Projects *(audio in Portuguese)*
http://rvarg.as/bm

The purpose of this article is to conceptualize and identify troubled projects and allow their evaluation and possible recovery, minimizing the impact of the negative effects in the event of a total failure. The word recovery, as used here, has a meaning that is different than usual. It does not mean leading the project to the intended success from the planning phase but to minimize total failure.

Currently there are lots of papers and studies on project management tools, methodologies, strategies, and processes. All these efforts are intended to enable and prepare project managers and their teams to ensure the success of their projects. BERRY (2002) complements this concept saying that virtually all the methodological patterns of projects are an important knowledge base on how to properly conduct a project, completing the work within its deadline, and with high-quality deliverables.

However, the reality that many project managers make evident is significantly different. In fact, even the most experienced project manager end up as acting as a "firemen" to their projects, trying at any cost to solve the problems and the difficulties found along the road.

These "Troubled Projects" are a reality in the worldwide business scenario; most of the times, dealing with a troubled project is a particularly challenging task for the project manager and his or her team. These projects require, for different reasons, specific attention and care.

Finally, the article deals with lessons learned with troubled projects and how to use them to avoid future problems.

Definition of Troubled Project

A troubled project can be defined as a project where the difference between what is expected and what has been accomplished exceeds the acceptable tolerance limits, pushing into a course that will inevitably lead to failure.

By assessing the nature of the projects, we can say that any project is characterized by a challenge, whether for its intrinsic complexity or its short deadline or low cost. To this regard, any project requires a level of control and management different from usual engagements, many times demanding a differentiated effort from the project manager and his/her team.

However, when the variances exceed an acceptable limit of tolerance we have a troubled project that requires a specific effort. In this case, a specific approach strategy becomes necessary, by defining a possible recovery or even deciding for an early termination.

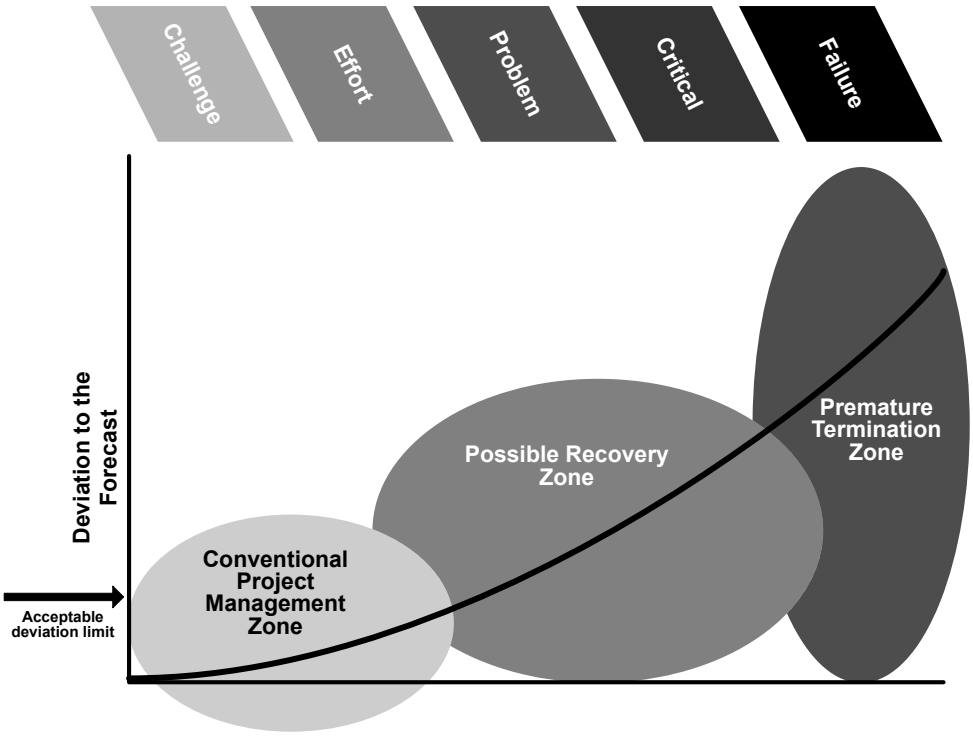


Exhibit 01 – Continuous sequence of troubled projects (ESI, 2005).

It is important to note that troubled projects are not failed projects. Failed projects are unrecoverable, since the highest level of loss possible has been reached. On the other hand, the troubled project has a possibility of being recovered although it shows strong indications that if it is not managed in a specific manner it can quickly deteriorate and become unfeasible.

When we use the term "recover", what we mean is that there is a chance of recovery and not that the recovery is simple or easy. Exhibit 02 shows some of the erroneous perceptions regarding troubled projects.

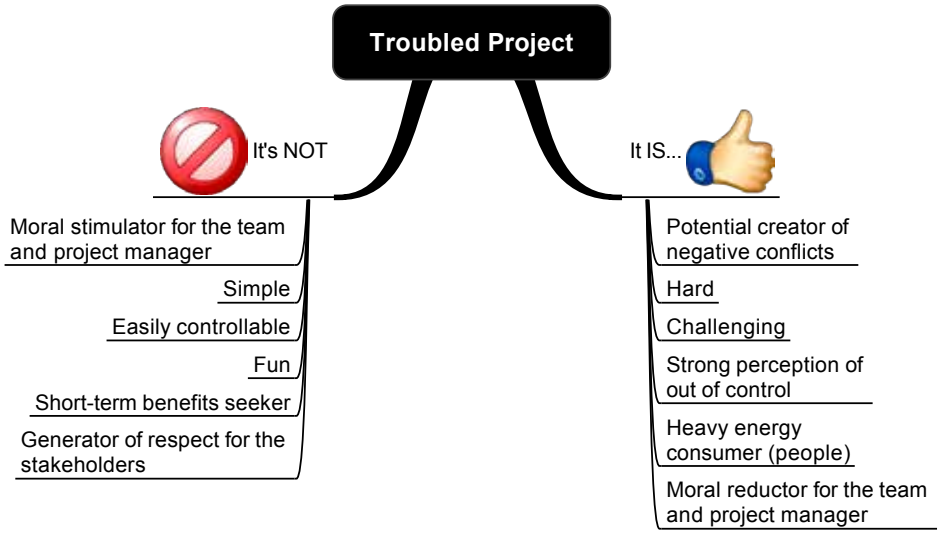


Exhibit 02 – Erroneous perceptions on troubled projects.

Identifying and Assessing a Troubled Project

A troubled project always presents indicative factors that might help recognize it as a problem. Some aspects related to stakeholders, project resources, documentation, and the triple constraint (scope, cost, and schedule) allow us to get a quick, direct perception of the problem degree the project is in, as shown in Exhibit 03.

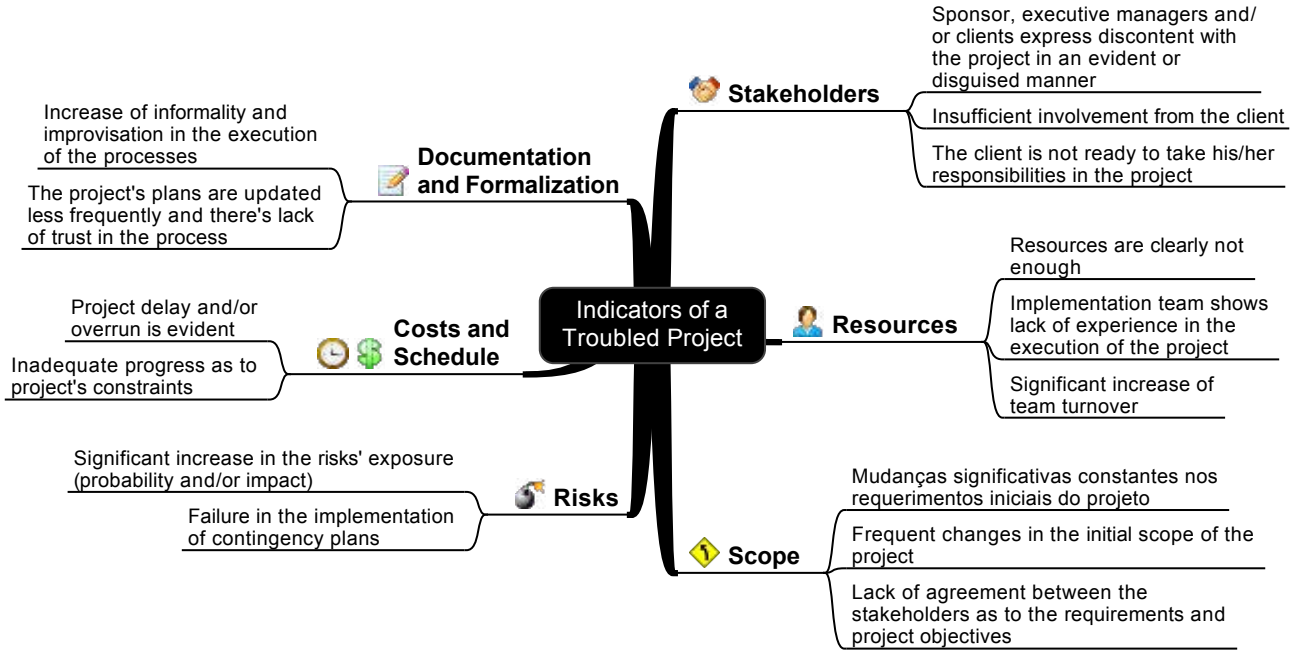


Exhibit 03 – Mindmap of the indicators of a troubled project.
Based on SAROKIN (2005), WU (2000), and WARD (2003).

Although the aforementioned warnings are quite straightforward, it is important to highlight that none of them indicates that a project is an isolated problem. Most of the times, they operate together and indicate, in several ways, that there is a problem with the project.

In addition to the warnings listed before, a set of vital signs and qualitative assessment models can be built to develop a more accurate criterion on the real vitality of the project. KAMPUR (2001) says that the vital signs are measured by the variance between current status of the project and the values as planned, as shown in the example in Exhibit 04.

VITAL SIGN	VARIANCE	SCORE
Percent variance between actual and planned schedule	< 10%	0
	10-20%	1
	> 20%	2
Percent variance between actual and budgeted cost	< 10%	0
	10-20%	1
	> 20%	2
Percentage of contractual deliverables completed on schedule	> 90%	0
	80-90%	1
	< 80%	2
Percent variance between resources actually used and budgeted resources	< 10%	0
	10-15%	2
	> 15%	4
Number of risk events with high probability and high impact	1-3 Risks	1
	4-5 Risks	3
	Above 6 Risks	5

Exhibit 04 – Example of vital signs models (KAMPUR, 2001).

ESI International (ESI, 2005) developed an assessment process of troubled projects based on a process of interviews, analysis and consolidation of results that allow us to assess the problem's potential and the chances of recovering the project. The process is highlighted in Exhibit 05. In this process the participation of the main stakeholders and their personal perceptions are the key to the success of a possible recovery of the project.

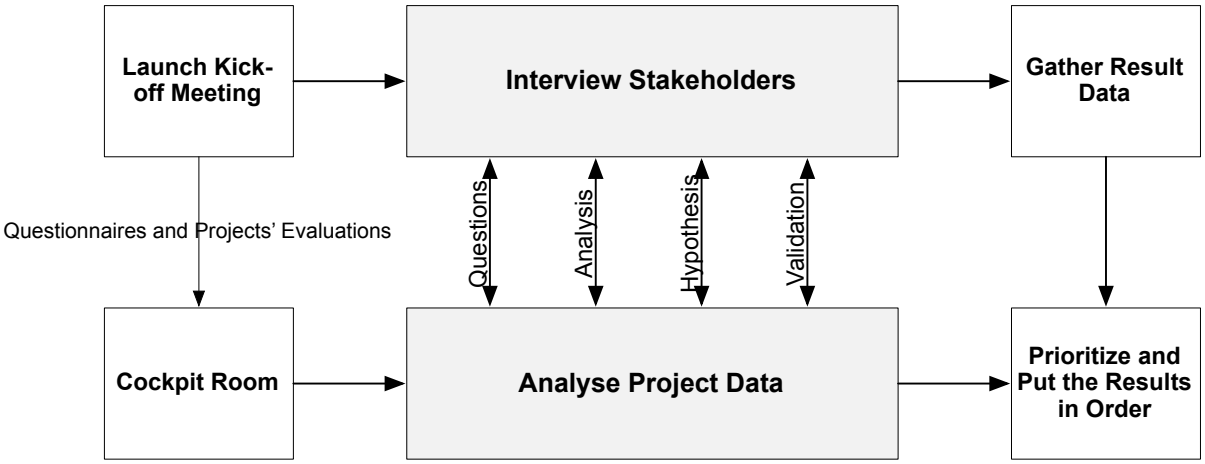


Exhibit 05 – Troubled project assessment model (ESI, 2005).

Several other models can be developed to identify scenarios in each organization. However, all these models should include a brief, quick, direct assessment; otherwise, when a project is identified as a problem it might be too late to recover it.

Project Recovery vs. Project Termination

Once the troubled project is assessed, we have to make the decision of aborting or recovering the project. Different factors may influence this process, but some basic considerations have to be observed. LONG (2003) proposes five key questions that should be considered to decide if the project will be recovered or aborted, as follows:

1. How important is the project for the sponsor, the stakeholders, and the organization?
2. Can the project continue as planned and defined or does it need to be completely redefined?
3. The organizational impacts and the resource needs for the recovery are feasible to produce the desired recovery?
4. Is there a need for political support so that the project can be recovered?
5. Are you (the project manager) personally motivated and interested to do what needs to be done to recover the project?

As a complement to the five previous questions, several factors can evidence that there is no chance of recovering the project. The most common factors are as follows:

- Business benefit to be generated by the business cannot be delivered
- The political environment is no longer sustainable
- There is no longer a project sponsor and there is no apparent capacity to replace them

- The business needs have changed
- There have been significant changes in technology
- Contractual or judicial dispute in progress that makes the project unfeasible
- Market conditions have changed

If you decide to discontinue the project, its early termination can be carried out in two different ways, each with its own level of complexity, speed, and stress.

STEWART & SHEREMETA (2000) assessed the different drivers and impacts involved in the early termination of a project. They say that there are basically four ways to terminate a project, as follows:

- **Addition** – Discontinue the project by adding the work to be performed and all its resources to a larger project.
- **Absorption** - Discontinue the project having another project absorbing the work of the troubled project, without the resources and infrastructure accompanying the work.
- **Inanition** - Discontinue the project by inanition (starvation), with the resources that sustain the project no longer being supplied, and the project being terminated due to complete lack of resources.
- **Extinction** - Discontinue the project by extinguishing it, with an immediate cancellation action being taken, and the project ceasing to exist and only the work already completed and that can possibly be used is recovered.

In order to group all these concepts, we developed the flow chart in Exhibit 06, starting with the problem assessment up to the possible recovery strategies and the early termination of the project.

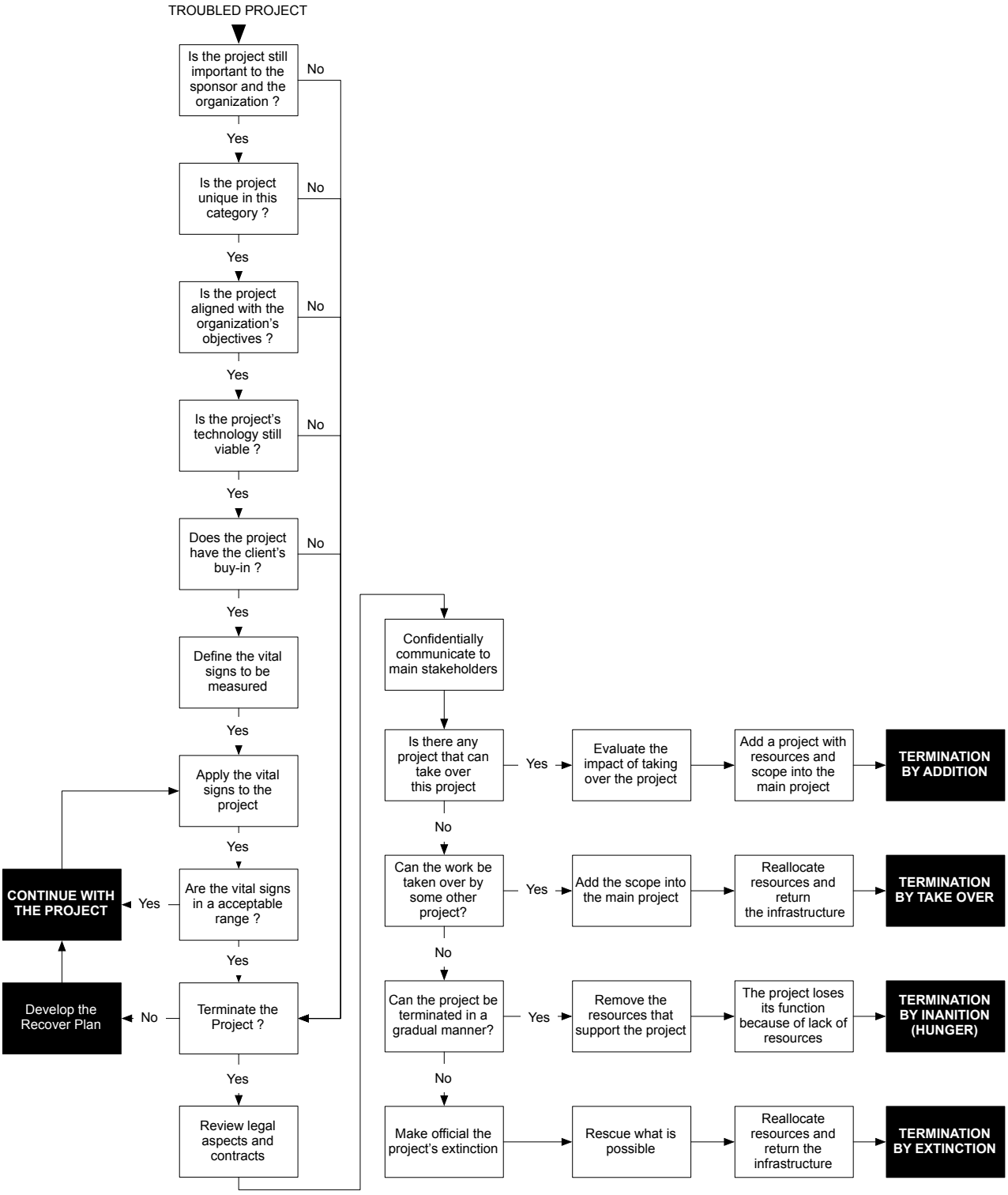


Exhibit 06 – Flow chart of the decision-making process identification regarding a troubled project.

Regarding the decision on project recovery or termination, we should emphasize that there is no formula or quantification to suit all projects, in all organizations. Many times the search for the desired results can include the cancellation or anticipated termination of a project.

Developing the Recovery Plan

When a recovery strategy for a project is prepared, many say that it is not important to know what drove the project to its current status but rather to see what can be done and will be done to pull it out of that situation. However, this statement is incorrect. It is very hard to have a correct recovery strategy without knowing the facts that created the problem. Particularly, if the drivers are not eliminated, the project might be recovered in the short term, but with time it can fall back into the same critical stage it was before the recovery process.

Another important issue is that recovering a project is to save the loss and restore its usefulness, preventing the project's total failure (ESI, 2005). Thus, when we intend to recover a project we are not discussing the full recovery of the project, but the avoidance of its total failure.

Basically, recovery consists of readjusting the basics of the scope, schedule, and costs and resources of the project, which is methodologically known as the project's triple constraint, as shown in the project triangle in Exhibit 07.

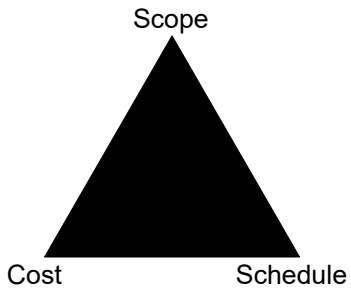


Exhibit 07 – Project's triple constraint (scope, schedule, and cost).

The proposals below can be discussed and assessed based on these constraints.

Option 1 – Reducing the project scope, maintaining the planned budget and schedule. This process can save parts of the project that may survive without full scope, as shown in Exhibit 08.

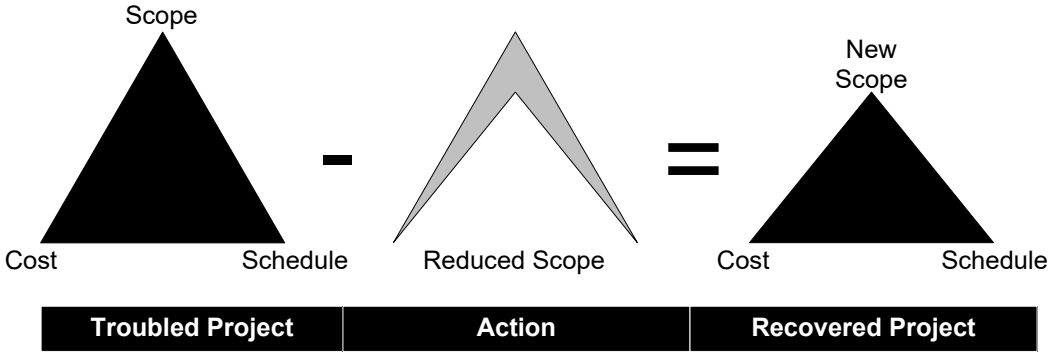


Exhibit 08 – Project recovery by reducing scope.

Option 2 – Maintaining project scope, inflating project costs and maintaining

the planned schedule. Usually this process is used when project scope cannot be reduced and the interest in results outweighs the shortfall caused by an increase in costs (Exhibit 09).

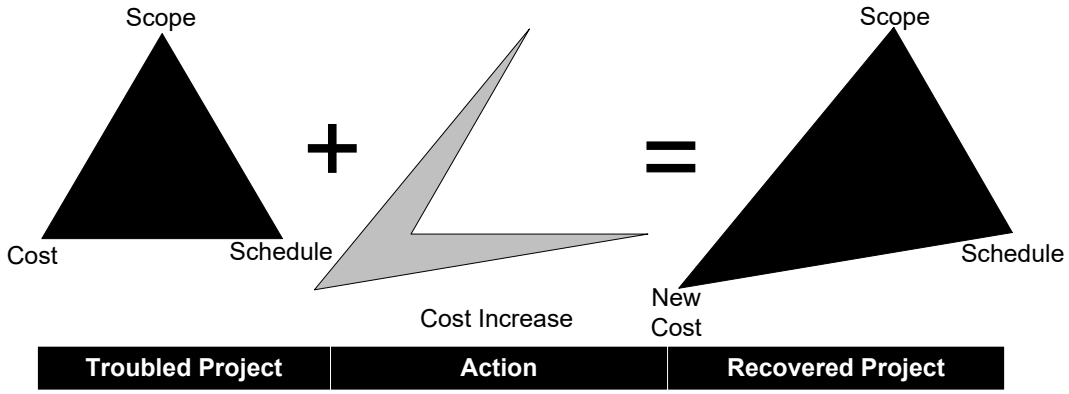


Exhibit 09 – Project recovery by increasing available budget.

Option 3 – Maintaining project scope by extending project deadlines and the budget forecast. Usually this is used when schedule is not essentially critical for the project, where a slowdown may avoid an increase in cost, thus allowing us to maintain the scope (Exhibit 10).

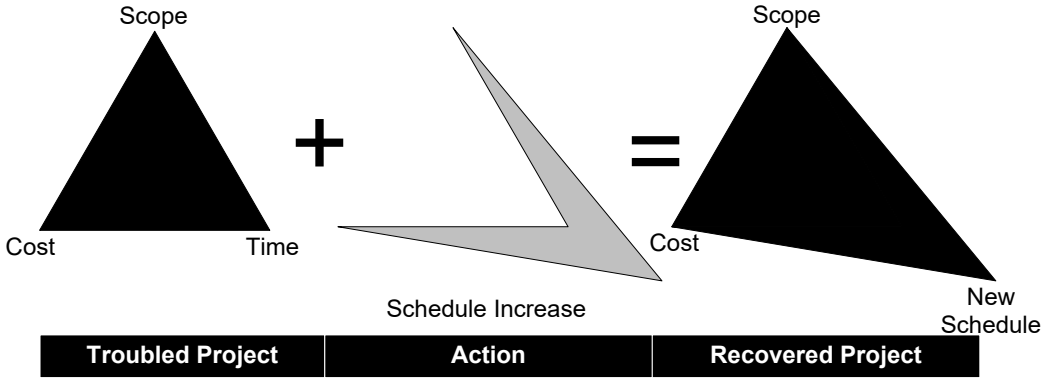
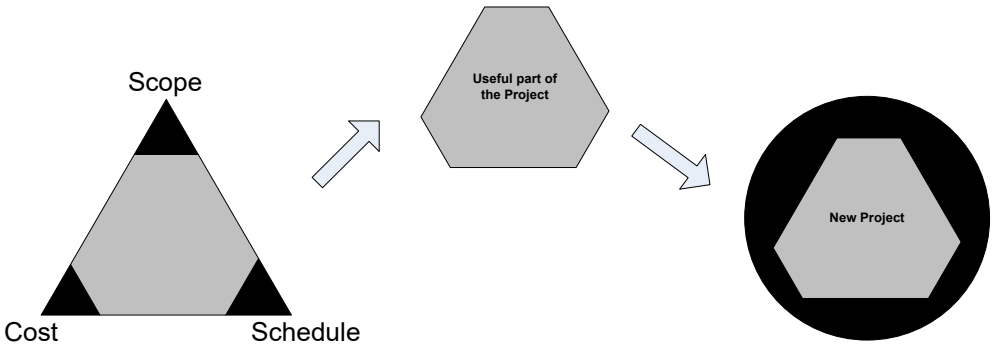


Exhibit 10 – Project recovery by extending schedules.

Option 4 – The project is totally redefined, thus creating a new relationship between scope, schedule, and cost, with only portions of the original projects scope. Usually this is used when options 1 to 3 are not considered as appropriate (Exhibit 11).



Troubled Project	Action	Recovered Project

Exhibit 11 – Full redefinition of the project, using part of the results obtained.

The four options shown above are the foundations for any type of recovery. All other types and solutions proposed are but variations resulting from one of these options.

In addition to this resizing of the triple constraint, several other actions should be taken to ensure that the recovery attains the expected success. In these cases, it is necessary not only an radical change in planning or in project requirements, but also a radical change in the behavior of the people. LONG (2003) mentions various actions that the project manager and the team should take to ensure the success of the recovery plan, as follows:

- Restructure the project team and/or increase the controls over the work.
- Politically consolidate the project with its sponsor, company executives, and stakeholders, searching for broad, unrestricted support.
- Create a solid communication program with a positive message in connection with the changes.
- Conduct and maintain an optimistic attitude and environment and, hoping for success.
- Ensure the personal commitment to assure the success of the recovery strategy.

Recovery Plan Success Factors and Lessons Learned

When conducting the assessment of the troubled project and its possible recovery it is possible to say that some of the lessons learned need to be presented again:

- *Always prioritize* . There is never time or money to solve all problems.
- *Be aggressive.* Look for the problem and find the solutions.
- *Proactivity.* Do not wait for problems to be solved on their own.
- *Establish accountability lines.* Know who is responsible for what within the project.

- *Worship experience*. The authority to make decisions should be transferred to the most experienced person and not necessarily to the highest hierarchical position.
- *Find the problems*. Try to identify the problems in a structured way and as a team, thus avoiding that the project be found due to its problems.
- *Do not micromanage*. Details prevent the whole from being easily identified.
- *The real problem may not be evident*. It is not always that what needs to be solved is what is more apparent in the project. Check what is behind the curtains.
- *Look for and assess the impacts*.
- *Never miss opportunities*. An opportunity lost can be one of the biggest problems for the project.
- *Poor decisions hurt*. Making a wrong decision is as harmful for the project as not deciding at all.
- *Contextualize opinions*. Outside opinions need to be inside a context and must be integrated.

Finally, it is important to break the cycle that created the problem. You should always remember the rules of Newton's Law. This law states that objects in motion tend to stay in motion unless an outside force opposes them.

Conclusions

Preventing a project from becoming a challenge requires proactive action. First of all, recognizing that a problem exists is itself already a problem. The article "Why Bad Projects Are So Hard to Kill", published by Isabelle Royer in the Harvard Business Review in 2003 (ROYER, 2003) has, in its own title, the search for more answers on the difficulty to assess and solve problems. She says that this is due to an unconditional belief that the project, even when going through stages of complete chaos, will overcome the obstacles and be a success in the future. This perception is contagious; everyone ends up believing that in the future a "miracle" might occur and transform the project in a huge success.

Unfortunately, reality always proves to be the opposite of a "miracle". If we look again figure 1, we will note that when the ones involved really accept that there is a problem, then the problem no longer exists. Now, it is a failure.

Therefore, when are faced with a troubled project, the first thing to do is to accept that there is a problem and quickly identify its magnitude, and the actions that should be immediately taken.

In a project this close to danger, any day lost is a day that will never be recover.

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MODELLING LINE OF BALANCE SCHEDULES WITH START-FINISH RELATIONSHIPS

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Abstract

The use of the Line of Balance Scheduling Method (LBSM) has been increasing, especially by construction industry companies in Brazil, Finland and Australia. The method addresses to the particularities of construction projects more effectively than the Critical Path Method does. One drawback of the method is the unavailability of commercial software featuring the fundamentals of LBSM. Studies pointed this as a factor that prevents a more frequent use. Recognizing the potential of the method for managing construction projects, the objective of this paper is to propose methodologies for modelling Line of Balance schedules using CPM software. In order to model the schedule, the paper demonstrates the use of the "Start-Finish" logic relationship and its contributions for two different approaches for the modelling: Network and Linear Scheduling Approach. The first approach demonstrate the design of a CPM network, which simulates the structure and function of a Line of Balance, with the objective of benefiting from CPM calculations. The second approach drops the CPM calculations and focuses on modelling, tuning and balancing individual workflow lines to and from milestones activities.

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Introduction

Part of the planning effort in a project is directed toward determining the sequence of the activities in such a way that the execution goes on in the most efficient way possible. This sequencing is modeled using relationships between activities, called dependencies, which may be "finish-start" ("FS"), "start-start" ("SS"), "finish-finish" ("FF") and "start-finish" ("SF"). This link establishes a relationship between activities, where one of them is the predecessor (the activity that comes before logically) and the other is the successor (the activity that comes after logically) [10].

The Line of Balance Scheduling Method (LBSM) is a technique absent from the PMBOK® Guide since its first release in 1996 through the current 2013 edition; CPM network scheduling is the most prominently discussed [12,13]. This omission ignores a current trend in the construction industry. Civil construction companies from Brazil, Finland and Australia are satisfactorily using the LBSM [3]. Employing this technique is related to the efforts to incorporate concepts of Lean Construction into company project management systems, more precisely with the Last Planner® production system, developed by Glenn Ballard and Greg Howell, founders of the Lean Construction Institute® (LCI) [1].

The US Navy initially used the concept of Line of Balance as a technique for planning the execution of activities of the industry in 1942 [5]. General Electric later, working for the US Navy, used it not only as a planning tool but also as a controlling tool. In the United Kingdom, the method was adopted by the Nation Building Agency.

According to Shaikh, the increasing usage of LBSM (one that receives the most attention among others techniques) comes in recent years, when an increasing demand for cost control and resource optimization has forced schedules (and schedulers) to focus on more than just the critical path. He attributes the limited usage of the technique to the lack of powerful and user-friendly computer applications. The author insists that the most commonly accepted commercial scheduling software packages are based on the CPM using the precedence diagramming method as the network analysis algorithm [12].

Mubarak, writing about Linear Schedule Methods (LSM), recognizes the same phenomenon of the lack of acceptance in the construction industry despite its analytical advantages. The author considers a drawback the fact that there are no major software packages offering LSM capabilities. Mubarak affirms that the LSM is poised to be make a comeback, since many software packages are becoming available [7]. Zack Jr. and Collins reveal a survey from the UK construction industry that only 1% of the respondent companies use the Line of Balance, while 54% use bar charts [13].

The preference for the Line of Balance scheduling method for developing the project schedule is due to the fact that the "unit of production x time" configuration, instead of the usual Gantt chart configuration ("activities x time"), results in better visualization for the link between the flow of work of the different crews [1]. This allows a different perspective for the control of the project activities – with the Line of Balance, the focus of control is the rate of production of the working crews and not the control of individual discrete activities, which is the focus of the Critical Path Method, largely used [5].

Objectives

The LBSM offers a new perspective for construction project management and a potential for improving performance. Taking into account the diagnosis of the authors referenced above, the objective of this paper is to propose the modelling of a Line of Balance schedule using an acclaimed CPM based scheduling software, like Microsoft®[1] Project. In order to demonstrate this proposal, it is important to study how this method works.

In order to model the Line of Balance with CPM based structures, the most uncommon precedence relationship between activities, the "start-finish" relation may be utilized. Kerzner classifies the "SF" relation as the "least common type of precedence chart" [6]. Referring to the construction industry, Mubarak considers the "SF" logic relationships "uncommon" and "almost nonexistent", recognizing the other three as "useful" and "common" [7].

The PMBOK® Guide (2013) defines the "SF" logical relationship as "the completion of the successor activity depends upon the initiation of the predecessor activity " [10]. It is only cited to give a complete representation of all possible links, since this is considered a rare relationship. The first and second editions of PMBOK even advise project managers not to use relationships other than the most usual (finish-start), since they may cause "unexpected results"[9].

It is important to note that, when working with "Start-Finish" logical relationships, the predecessor is not the activity that happens chronologically before, while the successor is not the activity that happens chronologically after. The predecessor (the activity that comes before logically) and the successor (the activity that comes after logically) [10].

The main objective of this paper is to propose how to model a Line of Balance schedule, while the secondary objective is to investigate the "unexpected results" of this sort of modelling.

1 Microsoft® is either registered trademark or trademark of Microsoft Corporation in the United States and/or other countries.

Line of Balance Scheduling Method

Zack Jr. and Collins [13] define a Line of Balance schedule as a graphical display of scheduled units versus actual units over a given set of critical schedule control points on a particular day. Shaikh defines the Line of Balance as a graphical variant of the linear scheduling methods which considers an activity location as a dimension in the planning, thereby allowing the balancing of operations for continuous and efficient use [12]. This definition is similar to the one given by Kenley and Seppänen [5].

The Line of Balance proposes that the planning of the activities should be according to a rate of production, or cycle, meaning the number of production units delivered by a working crew, over a certain time [4]. Such concept is similar to the concept of takt-time from the Toyota Production System, a measure of time between two outputs in a production system [8].

An example showing a comparison of the regular Gantt chart and the Line of Balance for scheduling three tasks repeating itself continuously along four floors is presented as Exhibits 1, 2 & 3. The assumption is that the next task initiates when the working crew ends the task on the preceding production unit.

TASKS	DURATION	PREDECESSOR
Task 1	4	-
Task 2	2	Task 1
Task 3	3	Task 2

Exhibit 1 – List of Activities

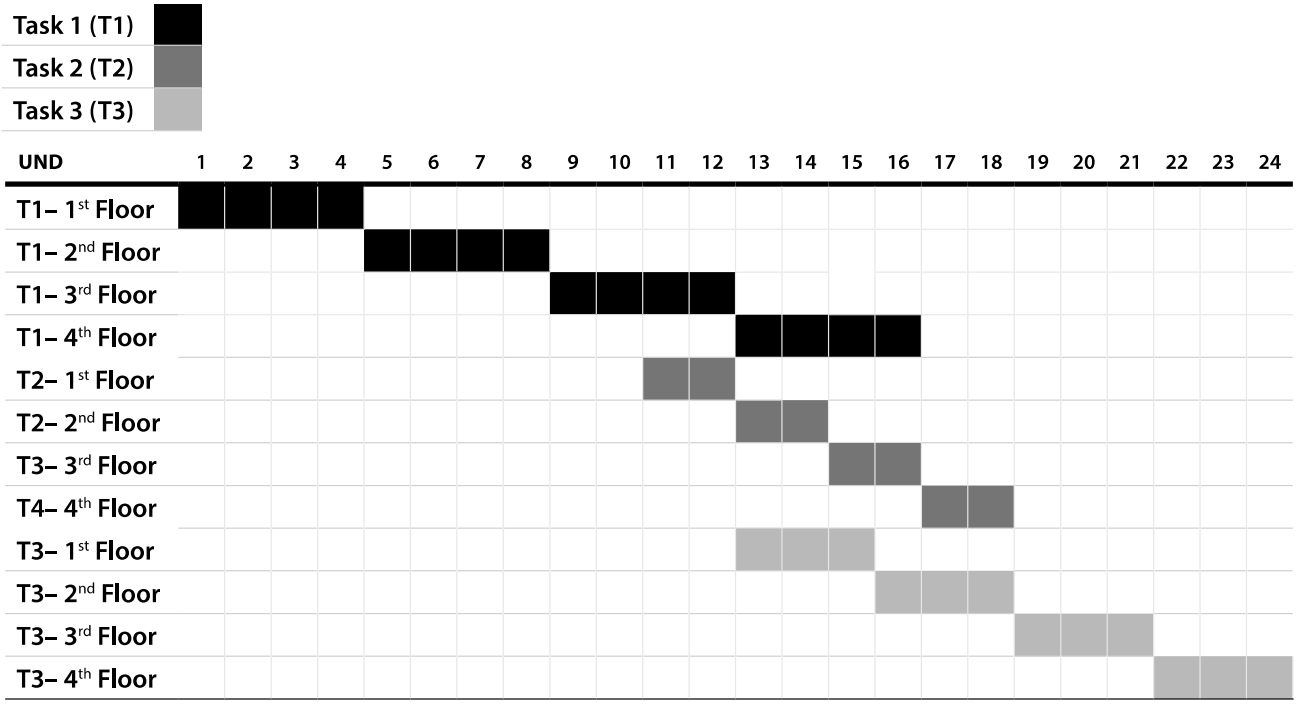

Exhibit 2 – Schedule Using the Gantt Chart

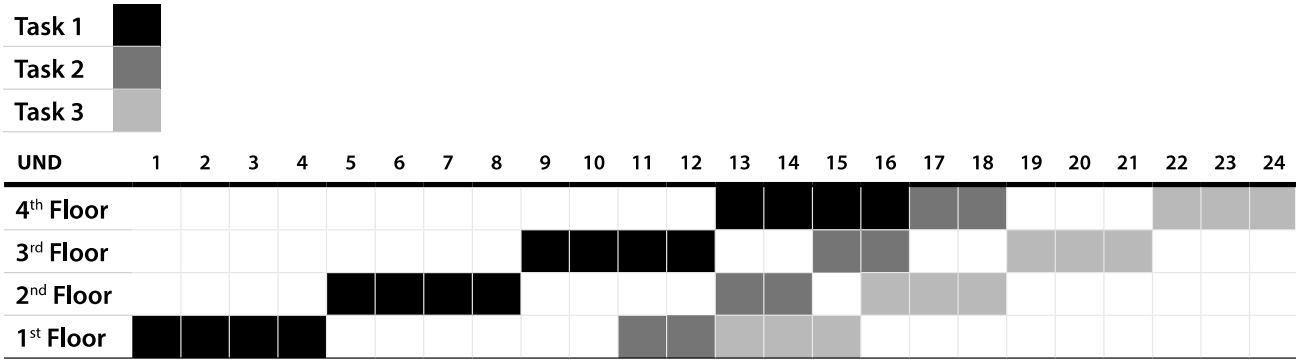

Exhibit 3 – Schedule Using the LBSM

The rate of production, or cycle, is the slope of each line (Exhibit 2 and 3). For Task 1 the cycle is 0.25 units per unit of time, for Task 2 the cycle is 0.50 units per unit of time and for Task 3 the cycle is 0.33 units per unit of time. The analysis of these cycle times allows the management team to balance the lines to optimize the use of resources and achieve a reduction of the time needed to complete the project. Exhibit 4 shows the result of reducing the amount of resources of Task 2 by half (in other words, reducing its cycle time to 0.25, the same value of Task 1, and increasing the Task 2 duration from two days to four days per floor).

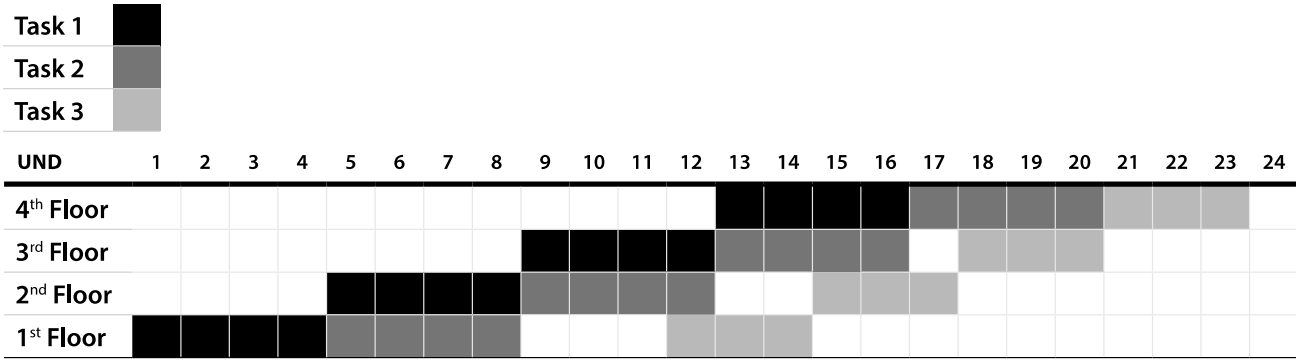

Exhibit 4 – Balancing Lines to Achieve a Schedule Reduction

The line balancing of these two activities allowed the project completion to happen one day earlier with the reduction of the resources used on Task 2 only – the remaining tasks were left untouched. The comparison of the Gantt chart and the Line of Balance also shows a significant reduction in the number of lines displayed on the schedule (from twelve in the Gantt chart to four in the Line of Balance). The large reduction on the example shows the potential to simplify the schedule chart of a real project that contains several repetitive processes like, for example, a building with 100 floors with "n" different kinds of tasks in each floor. The simplification factor is the number of tasks inside each repetitive process (also called production unit). If you have 100 km of road and 20 tasks for each km, by using the Line of Balance, you are reducing the number of lines of your Gantt chart by 20 (Eq. 1).

$$\textbf{\textit{Simplification Factor}} = \frac{\textbf{Number of Lines in a Gantt Chart}}{\textbf{Number of Lines in a LOB}}$$

$$\textbf{\textit{Simplification Factor}} = \frac{100 \text{ units} \times 20\frac{\text{task}}{unit} \times 1 line/task}{100 \text{ units} \times 1 \text{ line/unit}} = 20$$

EQ 1 – Simplification Factor

It is important to note that even though the example used cycle of tasks, it is possible to model a Line of Balance with process cycles, deliverables and sub-nets of precedency diagrams [5]. In addition, the example used floors, but it can also be used for houses, apartments, locations of a building floor, linear sections of a highway or pipeline, etc.

In the civil construction industry, the repetition of activities is commonly scheduled continuously [5]. Exhibit 6 shows the activities listed in Exhibit 1 modeled without the constraint of continuous repetition.

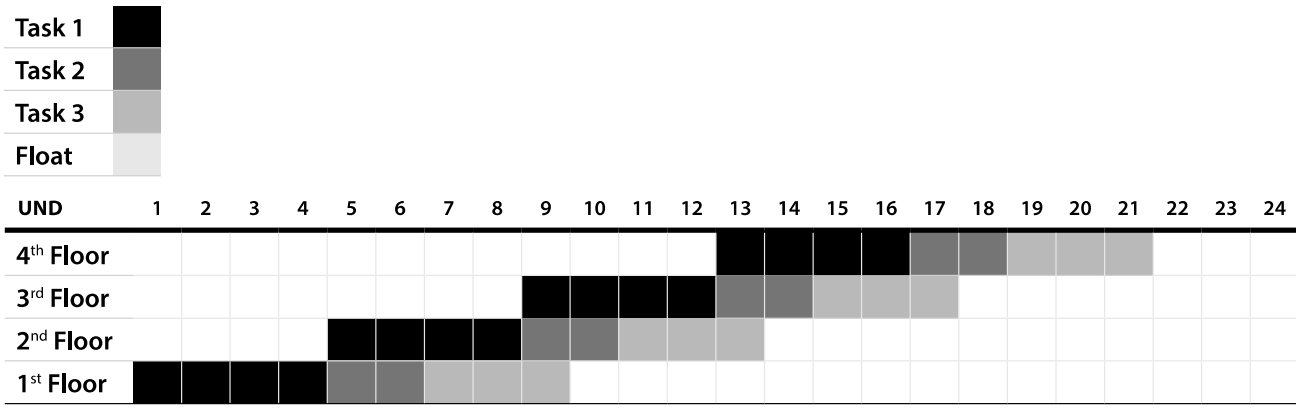

Exhibit 5 – Line of Balance Without the Continuity of Repetition

On the resulting Line of Balance, the sequence of tasks is finishing on the 21st day (3 days earlier). This happens because there is now a lack of continuity in the Task 2 and Task 3 lines. The new configuration presents a rate of production of 0.250 units/day for Task A, 0.286 units/day for Task B, 0.267 units/day for Task C. As presented earlier, the balancing of the lines result in a shorter overall duration for the project.

However, it is important to notice that this is not always a good practice. For example, in a construction project where a skyscraper is the product, or in a smaller scale real estate project, the deliverables cannot be transferred in a "first in-first out" routine. They are transferred to the client in a single batch. Therefore, the measure showed on Exhibit 5 would increase the inventory of completed work. It is possible to see, while examining Exhibit 5 that the first floor would wait 12 days, while the second and third would wait 8 and 4 days respectively, which results in a total of 24 days. The Line of Balance of Exhibit 3 has a total of 18 days,

25% less.

Another relevant consequence of breaking the continuity is that resources will remain for a longer amount of time allocated on the project. On Exhibit 5, the resources of Task 2 would be dedicated to this project for 14 days, while at Exhibit 3 the total time is only 8 days (about 43% less). For Task 3, the modeling pattern of Exhibit 6 results in 15 days of its resources, while the modelling of Exhibit 3 results in 12 days (20% less). This would imply a larger human resources cost for the project due to two main reasons:

- Underutilization of resources, since the crew assigned to task 2 would be idle for 6 days in total. In Brazil, the average labor cost for residential buildings is about 50%, according to indexes published by the Brazilian Chamber of Construction Industry [2]. POPESCU, PHAOBUNJONG and OVARARIN inform that construction projects' labor costs range from 30 to 50% [11];
- Demobilization and remobilization of crews, that is described by KENLEY & SEPPÄNEN [5] as a source of cost (and mostly schedule) uncertainty in construction projects, especially when the amount of time between demobilization and remobilization is short (one or two weeks). This inefficiency can results in a riskier schedule.

The management team has to study carefully the consequences of breaking the continuity in order to decide what the best option for the project schedule is. The tradeoff between shorter durations and the increase of risk and costs must be taken into consideration.

It is relevant to point out that describing the entire potential of the LBSM is not the purpose of this paper. The examples presented here are extremely simplified usages in order to demonstrate a still considerably unknown scheduling method and how it can optimize schedules.

Now that we have evaluated how the LBSM functions, we are able to propose two directions for the modelling to occur: the network approach and the linear scheduling approach. The difference between these approaches is the use of the CPM network calculations – the first, Network Approach, accepts CPM, while the second, Linear Schedule Approach, does not.

The Network Approach

It is important to observe the situation shown on Exhibit 3, where two sequential tasks show different rates of progress. Task 1 has 4 days of duration and its successor, Task 2, has 2 days, which means that the Task 1 progression has a smaller slope than the Task 2 progression (meaning that it is slower). Modeling the cycle of the continuous repetition of Task 1 can be done by using the standard "FS"

(finish-start) relation, since the next task initiates immediately after the working crew ends the task on the preceding production unit.

To allow the same continuity for Task 2, it is necessary to base the modeling of its cycle at the end of the last repetition of Task 1. Task 1 on the fourth floor already has a "FS" relation with Task 2 on the fourth floor. This way, the start date of Task 2 at the fourth floor is well defined on time. The described sequence is detailed in Exhibit 6.

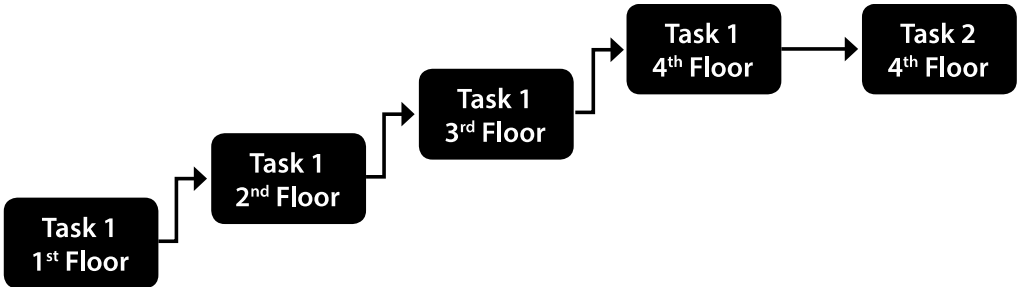

Exhibit 6 – Network Diagram With the Logical Relationship Between Tasks

Modeling the preceding repetitions of Task 2 on the lower floors using the "FS" relationship is not sufficient to ensure that the work can be performed continuously and efficiently. The only way to ensure this is by using a different logical linkage, one that can transfer the constraint defined by the cycle of repetition of Task 1 "downward" from Task 2 on the fourth floor to Task 2 on the first floor. Therefore, with the definition by the Project Management Institute® (PMI®), the predecessor in this case is Task 2 on the fourth floor, despite the fact that this is currently the final repetition in the schedule; it offers the time constraint for the sequence of tasks. The successor is, then, Task 2 on the third floor – a task that happens earlier than its predecessor does, but has its timing defined by the task that comes next on the time schedule [10].

This relationship between these two tasks is different; the start of the task that happens later in time is connected to the end of the task that happens immediately before. This represents a legitimate "start-finish" relation. The result is that the start of Task 2 on the fourth floor is linked to the end of Task 2 on the third floor that has its start linked to the end of Task 2 on the second floor that has its start linked to the end of Task 2 on the first floor (Exhibit 8). Note that Task 2 on the second floor has two predecessors, a "finish-start" link from Task 1 on the second floor, and a "start-finish" link from Task 2 on the third floor.

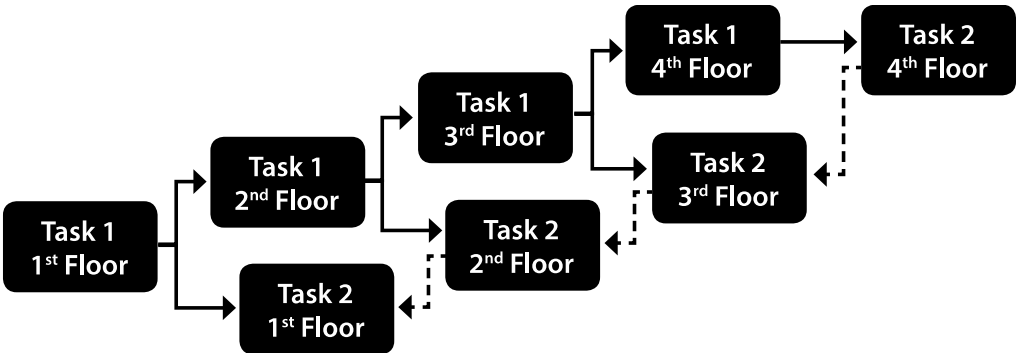

Exhibit 7 – SF Relation Between the Repetitions of Task 2

As we continue to model the network diagram, the fourth floor is no longer the time constraint for the cycle of the next set of tasks. From Exhibit 3, it is possible to perceive that the Task 3 progression has a slope that is smaller than the Task 2 progression (in other words, it is slower). To maintain a continuous, uninterrupted progression for Task 3, it must proceed from the end of Task 2 on the first floor "upwards" (from the first until the fourth floor). This sequence can therefore be modeled by using the "FS" relation, connecting the end of Task 3 on the first floor with the start of Task 3 on the second floor, which has its end linked with the start of Task 3 on the third floor. Finally, Task 3 on the third floor has its end linked with the start of Task 3 on the fourth floor.

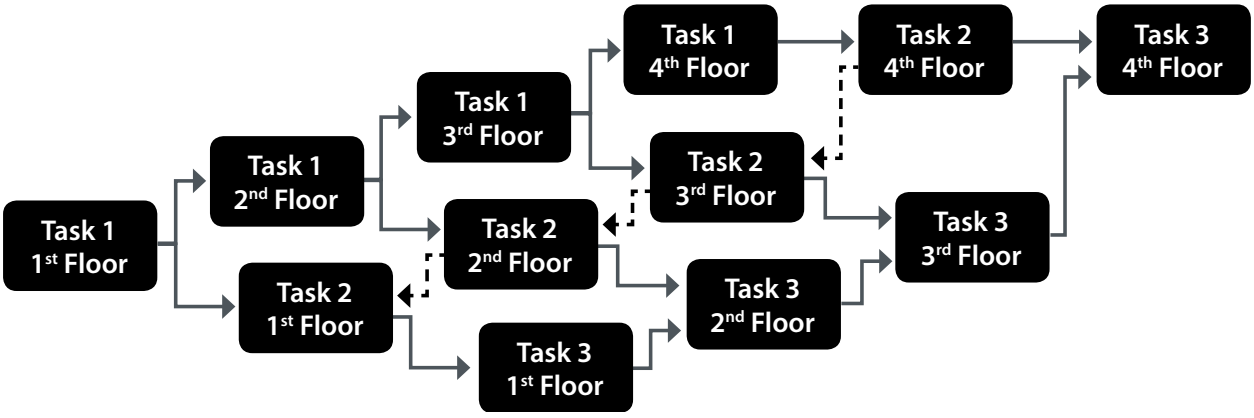

Exhibit 8 – Complete Network Diagram for the Example

A peculiarity can be observed when modeling this network diagram using CPM schedule management software in order to identify the critical path. The result displayed by Microsoft® Project states that every single task on the network is part of the critical path. Analyzing the progression of Task 2, it is true to say that every delay on a task will delay the following repetition. Although, we can observe in Exhibit 9 that there will be no delay on the project end date if Task 2 on the second floor has a one-day delay. In the same way, Task 2 on the third floor can absorb a two-day delay and Task 2 on the fourth floor can absorb a three-day delay without affecting the project completion date.

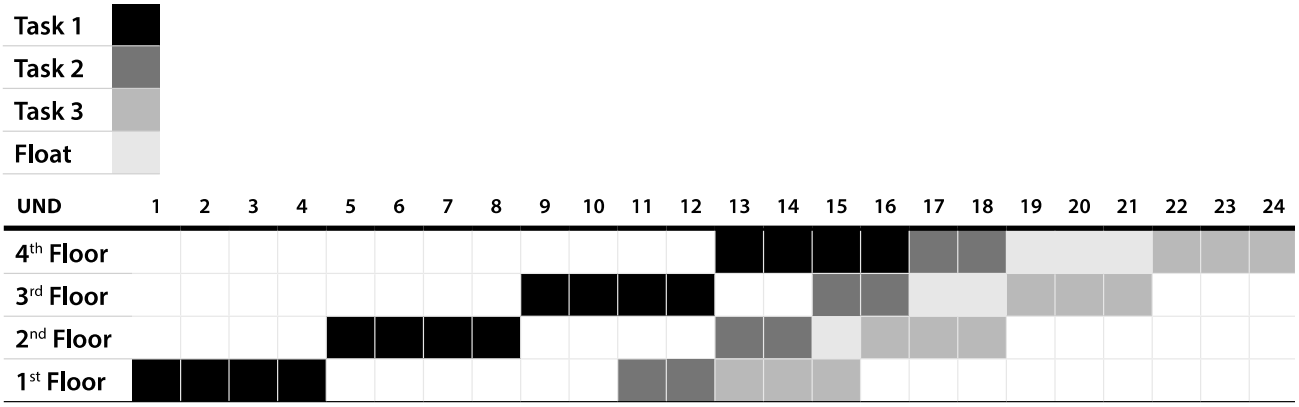

Exhibit 9 – Total Float for the Repetitions of Task 2

On the PMBOK (9), the critical path is "normally characterized by zero total float", while the definition of "total float" is "the amount of time that a schedule activity can be delayed or extended from its early start date without delaying the project finish date or violating a schedule constraint". Mubarak (7), in turn, consider the critical path as a "continuous chain of critical activities from the start to the end of the project", defining "critical activities" as activities that can suffer no delay without delaying the project as well. The same is present on the work of Kerzner (6): "there is no slack time in any of the events on this (critical) path".

There is no doubt that the path shown by the software is, indeed, the critical path, since the path duration is equal to the project duration (this is also a characteristic of the critical path recognized by the authors cited above). Still, it should be noted that the inclusion of the "SF" relation on network diagrams reveals an "unexpected result". Although the Microsoft® Project (the software used) display a clear critical path in terms of project duration, there are "hidden" floats on the network. Thus, the downside of this approach is that the CPM calculations regarding floats will not suffice, demanding a manual analysis of the floats present at the schedule and how it can be used

There is a difference between modelling this schedule with the "FS" relationship and the constraint "As Late As Possible" – "ALAP". The Exhibit 10 shows the schedule designed only with "FS" relationships and the "As Late as Possible" constraint.

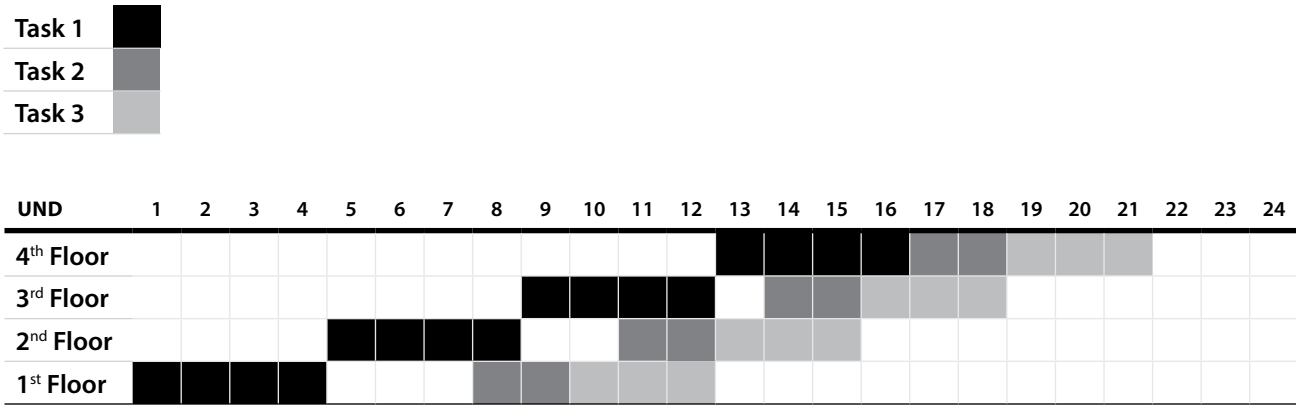

Exhibit 10 – Line of Balance Resulted from "FS" Relation and "ALAP"

It is possible to perceive that the Line of Balance is similar to the one at the Exhibit 5, in terms of duration, but with only one discontinuous task progression. The risk of schedule and cost related to the discontinuity remains and the resources for Task 2 progression remain assigned for a longer period. In addition, the Line of Balance above has the same inventory of completed work that the one presented on Exhibit 3.

It is important to note that the logical structures applied resulted in Line of Balances suitable to different set of contexts. The structure constructed with "SF" relationships will result in continuous lines, not susceptible to any risks related to discontinuity. The other logical structure, with "FS" relationships and "ALAP", will result in a shorter duration for the project with a higher risk exposure trade-off. In sum, both "SF" and "FS" + "ALAP" structures are valid for modelling a LB with a CPM software.

The management team, knowing the particularities of each model, will have to decide which one fits more properly to the project's context. If the risks associated with task discontinuity are worth taking in order to achieve scheduled duration reduction, the "FS" + "ALAP" structure should by applied. In cases where those risks are not worth taking, the "SF" structure should be preferred. In fact, a larger and more complex schedule may offer situations where both structures are present.

The Linear Schedule Approach

This approach uses the CPM software as a graphical tool for designing the lines and controlling the project along its life cycle, focusing only on the fundamentals of the method: the rate of production of each line and the balancing of all of them. The result, instead of a network, is a graph similar to the one presented on the Exhibit 11.

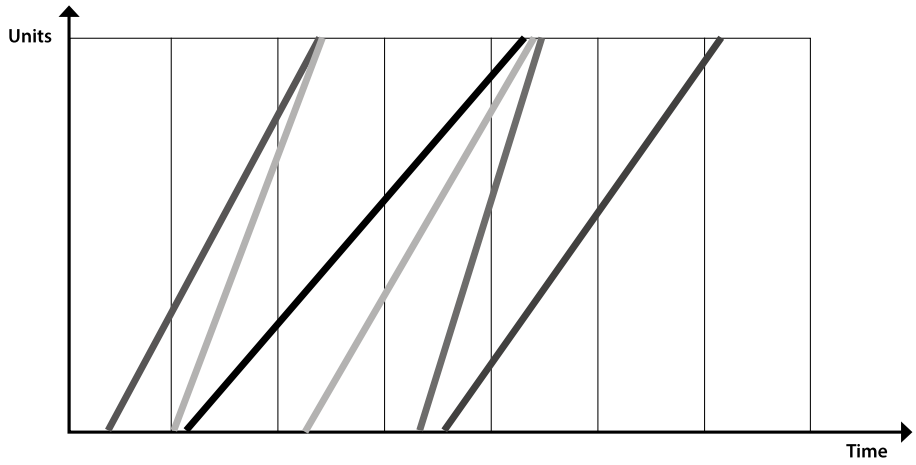

Exhibit 11 – The Linear Schedule Approach

Exhibit 11 shows each line as the representation of the progression of six repetitive tasks in a construction project. This methodology ignores the creation of a completely connected CPM network, focusing only on the design of the lines and then tuning them to an efficient configuration – meaning adjusting the distance between the lines and further balancing them. This proposition is not at all disconnected from the reality of project management in the construction industry, given that only 14% of respondents work with a fully linked CPM schedule, according to a survey performed in the UK [13].

This utilization is, in truth, a consequence of the definition of Line of Balance per se. Additionally, it benefits from the main idea behind the first methodology, that is to subordinate a sequence of tasks to an imposed time constraint. In the example given, the finishing date of the cycle of Task 1 imposes a fixed date to the end of the cycle of Task 2 (both lines becoming "linked at the top"). This approach focus on subordinating the sequence of repetition to a milestone.

On the subject of milestones, a practical example would be finishing a sequence of painting activities for a building by the end of the sixth month of the project, or the completion of the management plan should be by the third month after the project approval. Assuming that milestones in a network diagram are tasks with zero duration and with a fixed start date, the modeling of one of the examples is presented on Exhibit 12.

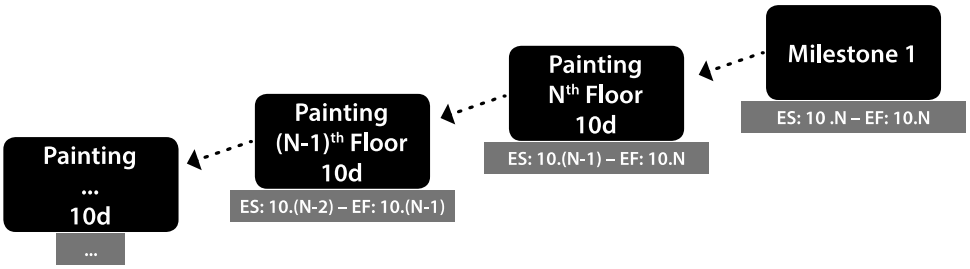

Exhibit 12 – Milestones and SF Relation

Exhibit 12 shows that Milestone 1 subordinates the end of the workflow of the painting activities. This way, the continuous use of SF relationships between the tasks' repetitions moving "downwards" will result in the necessary start date for the workflow. Equally, the sequencing may take its start on a milestone representing the beginning of the painting tasks, when the sequence is modelled "upwards" with the usual "FS" relationship. The example of the following is presented on the next Exhibit, where a sequence of sections of earthwork is subordinated to a milestone.

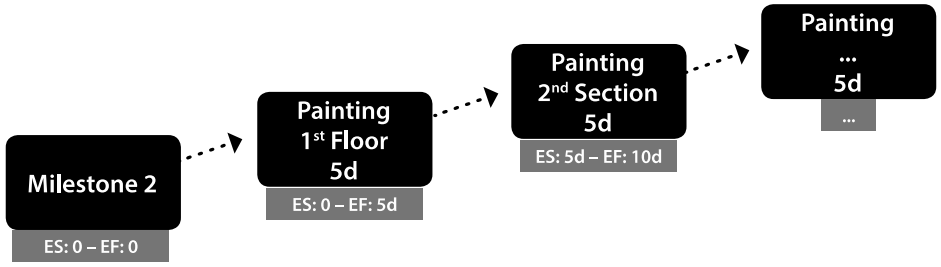

Exhibit 13 – Milestones and FS Relation

If the management team decides to schedule a non-continuous task progression, after considering the uncertainties and negative consequences, the line can be modelled using lags or leads. If the management team was to model the Earthwork task progression with a two-day lag between each section, it could be done like in the Exhibit 14.

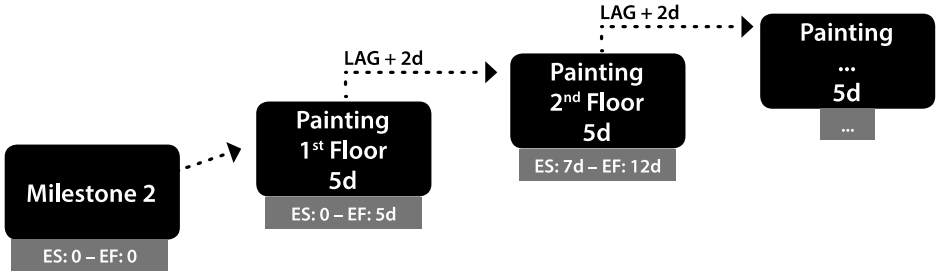

Exhibit 14 – Non-continuous Task Progression

Thus, a milestones chart, defined by the experience and lessons learned from previous projects or with expert judgment, for instance, can be used to initiate the process. The proposed methodology deals with either starting dates mile-

stones and delivery dates milestones.

At this approach, the schedule control's main goal is to prevent the clash between lines. The clash represents a rupture on the project workflow. Despite the fact that this modelling rejects the assignment of predecessors, the hard-logic relationships among the tasks remains. Accordingly, if a line "invades" another, one of the work crews will have to become idle until the situation is remediated or will have to be transferred. This can happen for either a line that is progressing with a higher speed than anticipated or a line that is progressing slower.

Without the CPM calculations, the control is done, in other words, only by the flow of work of the construction project as a whole. The clash is a consequence of an unbalanced execution, with task progressions going off track. Other consequence of lacking the CPM calculation is, evidently, that the management team experiences a paradigm shift. The CPM method delivers a clear priority for team: the critical path. The workflow perspective assigns to every single line the same rank of priority. The focus of the management team will derive from the information gathered from the execution.

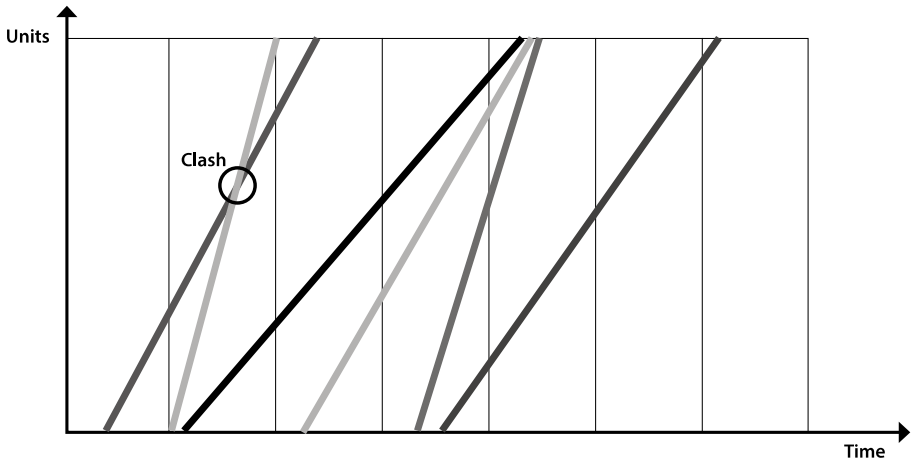

Exhibit 15 – Lines Clashing

Conclusion

This paper proposed the utilization of CPM software (as seen, the most largely used) as a tool for the Line of Balance Scheduling Method. Inherently, the CPM and the LBSM are different from each other. CPM, according to Kenley and Seppänen (5), focuses on how discrete activities connect to each other in order to identify the critical path. LBSM focuses on the perspective of flow of work, when the scheduling planning concerns with the production process of the particular production units (seemingly to designing a "factory"). Still, the scarcity of commercial software that covers its fundamentals is pointed as a barrier to its implementation and the CPM commercial software may supply a preliminary solution.

On the subject of the model, the paper proposed that the use of the "SF" relation could be of value for the modelling. The LBSM, its behavior and its peculiarities were discussed first and then two approaches for the modelling were proposed: the Network Approach and the Linear Scheduling Approach. Both were discussed and exemplified.

The first approach allowed the Line of Balance to be modelled as a CPM network. The continuous progression of tasks, as demonstrated, can be represented with the use of the "SF" relationship when the lines become "linked at the top". On the other hand, this usage implies on some "unexpected results" regarding the critical path, demanding further investigation from the management team for the situation of floats on the lines. The lines can be modelled with "FS" relationships and the "As Late as Possible" constraint as well, but the result does not guarantee the continuity of the task repetitions, exposing the project to risks related to work discontinuity. On the other hand, the resulting LB presented a shorter duration than the one structured with "SF" relationships. Both structures generated consistent results that may be valuable for different project contexts and even can be combined for more complex project schedules. Thus, it is the management team's decision which structure is more suitable for the project.

The second approach behavior accordingly with the definition of LBSM. The CPM calculation routine were dropped completely and the CPM software was used as a graphical tool for designing the lines that represent the task progressions and their control over the project life cycle. The "SF" relation employed a mean to subordinate the tasks to a delivery milestone, while the common "FS" relation was used to build the sequence from a start milestone. Connecting the task sequences to a milestone allows the scheduler to move them on the time scale with the goal of tuning the schedule and further balancing.

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RICARDO VARGAS

ADOPTING THE QUADRATIC MEAN PROCESS TO QUANTIFY THE QUALITATIVE RISK ANALYSIS

Accepted for publication at

PMI Global Congress 2013 – North America
New Orleans – Louisiana – USA – 2013

Abstract

Related Podcasts

♫ Using the Quadratic Average (Mean) in the Qualitative Risk Analysis
http://rvarg.as/bd

♫ Understanding the Risk Attitude
http://rvarg.as/6j

♫ RBS – Risk Breakdown Structure
http://rvarg.as/be

♫ Risk Management Special Playlist
http://rvarg.as/bc

The objective of this paper is to propose a mathematical process to turn the results of a qualitative risk analysis into numeric indicators to support better decisions regarding risk response strategies.

Using a five-level scale for probability and a set of scales to measure different aspects of the impact and time horizon, a simple mathematical process is developed using the quadratic mean (also known as root mean square) to calculate the numerical exposition of the risk and consequently, the numerical exposition of the project risks.

This paper also supports the reduction of intuitive thinking when evaluating risks, often subject to illusions, which can cause perception errors. These predictable mental errors, such as overconfidence, confirmation traps, optimism bias, zero-risk bias, sunk-cost effect, and others often lead to the underestimation of costs and effort, poor resource planning, and other low-quality decisions (VIRINE, 2010).

Qualitative X Quantitative Risk Analysis

One of the main challenges during the analysis of a risk is to define the right approach to assess the amount of the exposure/opportunity. The two basic steps to determine the right level of risk are based on the qualitative and quantitative analysis (Exhibit 1).

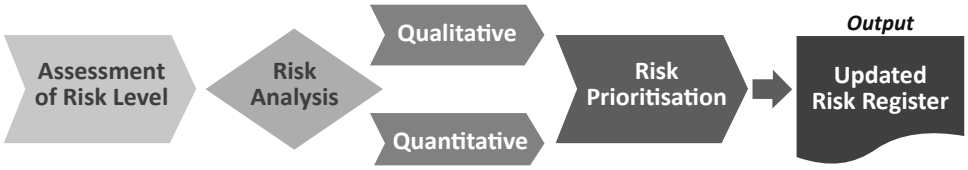


Exhibit 1 – Analysis of Risk Process Flow (ROSSI, 2007).

A qualitative risk analysis prioritizes the identified project risks using a predefined scale. Risks will be scored based on their probability or likelihood of occurrence and the impact on project objectives if they occur (Exhibit 2 and 3).

LEVEL		SCORE	FOR THREATS
High	Very High	5	Red
	High	4	
Medium	Medium	3	Yellow
	Low	2	
Low	Very Low	1	Green

Exhibit 2 – Example of scales used in the qualitative risk analysis

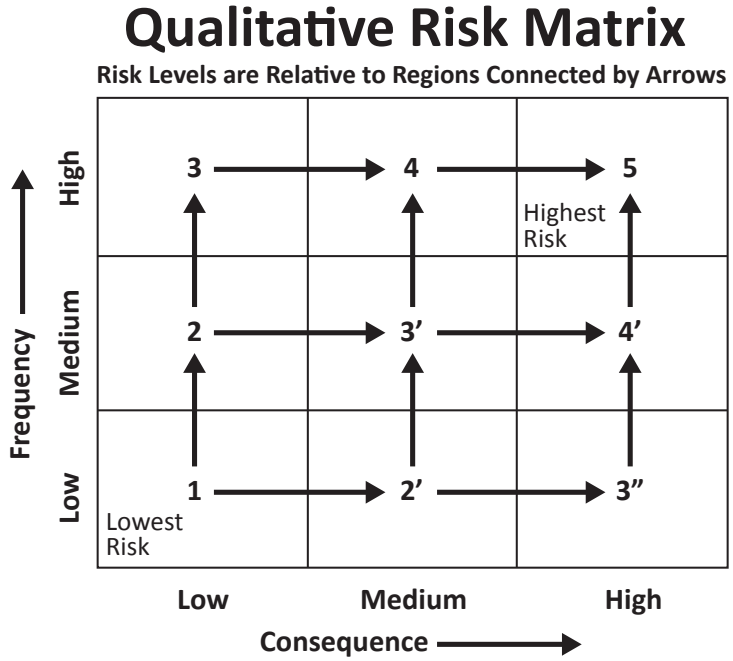


Exhibit 3 – Example of Qualitative Risk Matrix with 3 x 3 Levels (ALTENBACH, 1995)

A quantitative risk analysis is based on simulation models and probabilistic analysis, where the possible outcomes for the project are evaluated, providing a quantitative, numeric and many times financial risk exposure to support decisions when there is uncertainty (PMI, 2013). Some quantitative processes are simple and direct like rolling a dice (Exhibit 4), but most of them involve very complex simulation scenarios like the Monte Carlo Simulation.

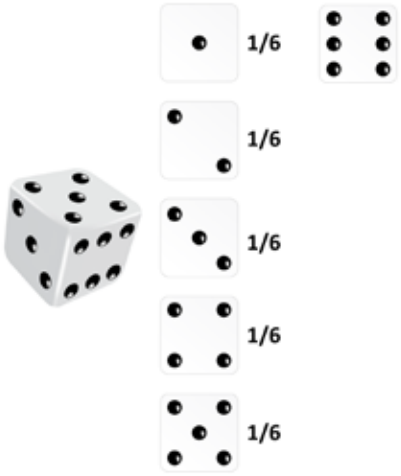


Exhibit 4 – Diagram showing the deterministic probability of rolling a dice

"Monte Carlo" was a nickname of a top-secret project related to the drawing and to the project of atomic weapons developed by the mathematician John von Neumann (POUNDSTONE, 1993 and VARGAS, 2013). He discovered that a simple model of random samples could solve certain mathematical problems, which couldn't be solved up to that moment.

The simulation refers, however, to a method by which the distribution of possible results is produced from successive recalculations of project data, allowing the development of multiple scenarios. In each one of the calculations, new random data is used to represent a repetitive and interactive process. The combination of all these results creates a probabilistic distribution of the results (Exhibit 5 and 6).

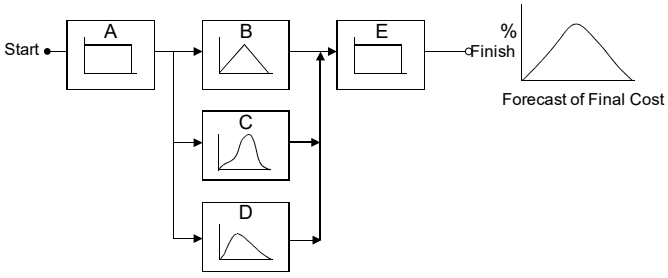


Exhibit 5 – Construction of model of distribution of costs and activities or work packages making up a final distribution from random data of the project (PRITCHARD, 2001).

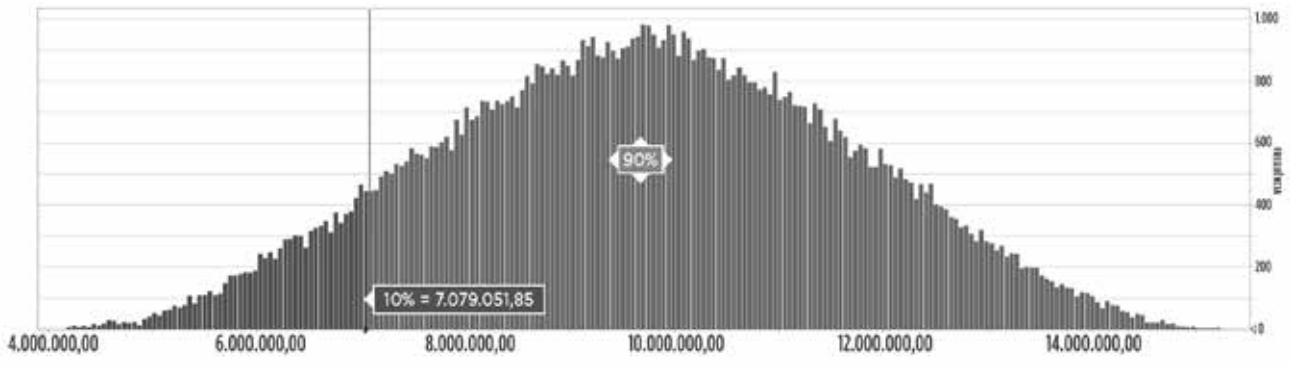


Exhibit 6 – Example of Monte Carlo simulation to assess the cost impact of a potential threat to the project

Because quantitative analysis is based on mathematics and statistics supported by objective metrics, such analyses are considered to be more rigorous (SMOCK, 2002). The main challenges of a solid quantitative analysis are the time and effort it requires to be executed and the required technical background in statistics to make the proper parameterization of the data. The main advantages and disadvantages of each method are presented in the Exhibit 7.

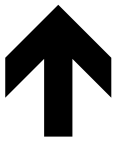
	QUANTITATIVE METHODS	QUALITATIVE METHODS
Advantages	Facilitates the cost benefit analysis Gives a more accurate value of the risk More valuable	Relatively simple to be implemented Easily determine risk categories with greater impact in the project Visually impactful
Disadvantages	Results of the method may not be precise Numbers can give a false perception of precision More expensive and time consuming	A lack of understanding of the parameters used in the scale can lead to different interpretations Results can be biased Less valuable

Exhibit 7 – Example of Monte Carlo simulation to assess the cost impact of a potential threat to the project (based on ROT, 2008)

The risk model proposed hereafter is a qualitative process with numerical results, reducing the ambiguity of the qualitative process without adds the time and effort to determine with precision the probability and the impact of uncertain events in the project.

Assessing Probability

The proposed qualitative probability assessment is based on a scale with their respective scores (Exhibit 8).



LEVEL	SCORE	DESCRIPTION
Very High	**5**	It is expected that the event will occur. If it does not occurs it will be a surprise.
High	**4**	The event has a great chance of occurring.
Medium	**3**	The event can occur.
Low	**2**	It will be a surprise if the event occurs.
Very Low	**1**	Very remote chance of the event to happen. Practically impossible.

Exhibit 8 – 5 Scales to assess the risk probability

For each identified risk a score from 1 (one) to 5 (five) should be determined.

5 Dimensions of the Impact

The impact of the event, in case it occurs, can be perceived in different dimensions of the project objectives. For example, one risk can have a major impact on costs but not necessarily an important impact in quality. It is very important to highlight that threats and opportunities should be analyzed separately.

The basic groups where impact should be evaluated are (Exhibit 9):

- impact on time and deadlines
- impact on costs
- impact on quality
- impact in safety and security
- other impacts

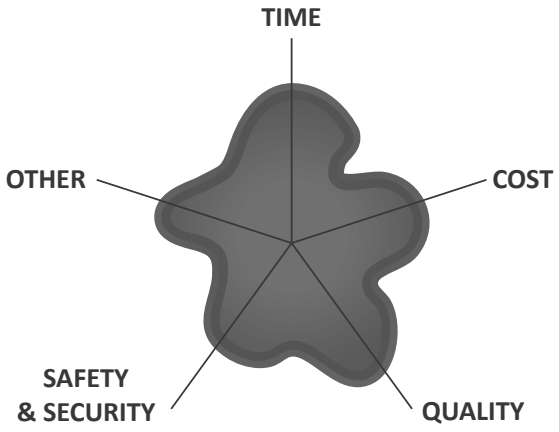


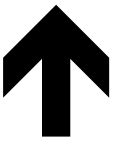
Exhibit 9 – Basic impact groups showing the different impact dimensions of one specific risk

Each project may develop different impact groups based on the nature of the project, including groups like: impact on reputation, regulatory impact, environmental impact, social impact, and stakeholder's impact, among several others. Following is the presentation of the 5 basic groups.

Impact on Time and Deadlines

One should assess the level of impact on the conclusion of the project. It can be positive or negative for opportunities and threats, respectively. Threats that impact the conclusion of the project must be considered as a priority if compared to other events.

Because each project differs in size, complexity and several other factors, the project team needs to agree on the level of tolerance that they consider appropriate for each level of impact, like the example shown in Exhibit 10.



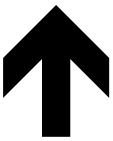
LEVEL	SCORE	DESCRIPTION
Very High	**5**	Delays/Anticipation above 180 days or 6 months.
High	**4**	Delays/Anticipation between 120 and 180 calendar days.
Medium	**3**	Delays/Anticipation between 60 and 120 calendar days.
Low	**2**	Delays/Anticipation between 15 and 60 calendar days.
Very Low	**1**	Less than 15 calendar days of delays/ anticipation.

Exhibit 10 – Example of impact scale and score for time and deadlines

Impact on Costs

One should also assess the level of impact that the event may bring to the total project cost. It can be positive (savings) or negative (additional expenditures) for opportunities and threats, respectively.

Like mentioned for time and deadlines, the project team needs to agree on the level of tolerance that they consider appropriate for each level of impact, like in the example for costs presented in the Exhibit 11.



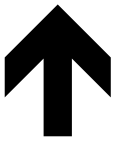
LEVEL	SCORE	DESCRIPTION
Very High	**5**	Variation (positive or negative) above $1,000,000.
High	**4**	Variation (positive or negative) between $500,000 and $1,000,000.
Medium	**3**	Variation (positive or negative) between $250,000 and $500,000.
Low	**2**	Variation (positive or negative) between $100,000 and $250,000.
Very Low	**1**	Variation (positive or negative) lower than $100,000.

Exhibit 11 – Example of impact scale and score for costs

Impact on Quality

Assesses the level of impact on the quality required for the project. It can be positive or negative for opportunities and threats, respectively.

As presented in the other groups, the project team needs to agree on the level of tolerance that they consider appropriate for each level of impact like in the example in Exhibit 12 for negative risk events.



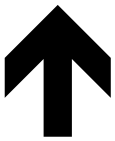
LEVEL	SCORE	DESCRIPTION
Very High	**5**	Client rejects the delivery or product.
High	**4**	Client asks for immediate corrective actions.
Medium	**3**	Client perceives and asks for action/ information.
Low	**2**	Client perceives but forgives and no action is needed.
Very Low	**1**	Imperceptible impact (most of the time not even perceived by the stakeholders).

Exhibit 12 – Example of impact scale and score for quality (only negative events)

Impact in Safety and Security

Assesses the level of impact that the event can incur in safety at work and security. This impact group could include or not aspects related to environment, physical security of the work in the project, data security (IT), and reputation, among others.

In the Exhibit 13, an example of scale is presented to assess impacts in safety and security.



LEVEL	SCORE	DESCRIPTION
Very High	**5**	Crisis. Impact is so evident and public that the project could not proceed as planned.
High	**4**	Evident impact on environment/reputation.
Medium	**3**	Impact is perceived and raises concerns.
Low	**2**	Perceived impact on environment/ reputation but without relevance.
Very Low	**1**	No impact on environment and reputation.

Exhibit 13 – Example of impact scale and score for safety and security, with focus in environment and reputation

Other impacts

This group is an optional group and aims to include any other specific impact of a risk that was not covered in the previous groups. It is important that the score of the other impacts, if it exists, should be from 1 to 5 like the other impact groups.

Proximity: The 6th Impact Dimension

Another dimension of the impact is the time horizon or proximity of the event (Exhibit 14). An event that may happen in hours requires different actions than another event that could impact the project in 2 years. If an event is close to happen, it has a higher priority if compared with future events (in the proximity aspect).

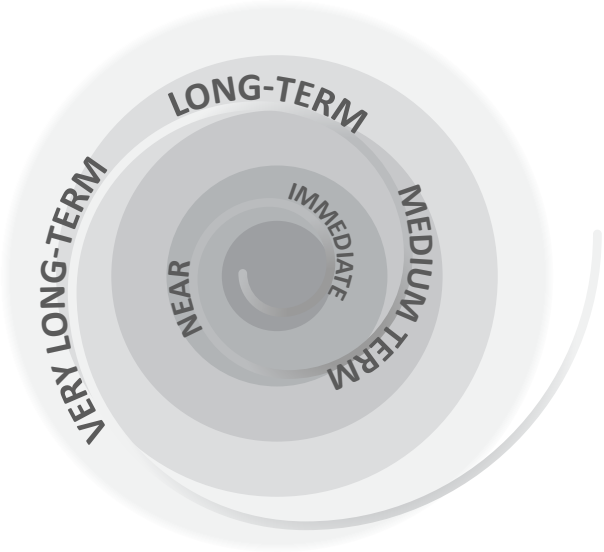


Exhibit 14 – Understanding the time horizon

The proximity scale should be compatible with the other impact groups (1 to 5 score for different time horizons). It is important that the project team defines what are immediate events, short-term events, medium-term events, long-term events and very long-term events (Exhibit 15).

It is important to highlight that immediate events will score higher than very long-term events when assessing their proximity.

LEVEL	SCORE	DESCRIPTION
Very High	**5**	Event can happen anytime in the next 15 days.
High	**4**	Event can happen between 15 days and 3 months.
Medium	**3**	Event can happen between 3 and 6 months.
Low	**2**	Event can happen between 6 months and 1 year.
Very Low	**1**	Event can happen more than 1 year ahead.

Exhibit 15 – Example of proximity scale and score

Calculating the expected value and final risk assessment

The expected value is a risk measurement used to assess and prioritize risk events (Exhibit 16).

$$Expected\ Value = Probability\ x\ Impact$$

Exhibit 16

Using the qualitative method, the probability will range from 1 to 5 (Exhibit 8).

The impact is based on the impact in different aspects of the project and the proximity using a quadratic mean (root square mean) calculation (Exhibit 17).

$$\boldsymbol{Impact} = \sqrt{\frac{Imp.\ on\ Time^2 + Imp.\ on\ Costs^2 + Imp.\ on\ Quality^2 + Imp.\ on\ S\&Security^2 + Imp.\ on\ Other^2 + Proximity^2}{6}}$$

Exhibit 17

The decision for the quadratic mean instead of the arithmetic mean is based on the concept that different levels of impact add additional exposure to the project and this variance should be considered as a risk factor to the project.

The relationship between the quadratic mean and the arithmetic mean is

$$Quadratic\ Mean^2 = Arithmetic\ Mean^2 + Variance$$

Exhibit 18

where the variance is a measure of how far a set of numbers is spread out

The variance concept is directly related to the dispersion of the different impact groups. If the impact ranges are very wide, the variance will also be high and the difference between the proposed quadratic mean and the traditional arithmetic mean will increase, increasing the risk impact.

One example of the impact results is presented in the Exhibit 19.

	IMPACT TIME	IMPACT COST	IMPACT QUALITY	IMPACT S&S	OTHER IMPACT	PROXIMITY
Risk A	**3**	**2**	**1**	**1**	**1**	**4**

$$\boldsymbol{Impact} = \frac{\sqrt{3^2 + 2^2 + 1^2 + 1^2 + 1^2 + 4^2}}{6} = \sqrt{\frac{32}{6}} = 2,31$$

Exhibit 19

It is important to highlight that the threats and opportunities can be calculated using the same formula, but with different signals (+ for opportunities and – for threats). The total qualitative risk exposure of the project is determined by the sum of the expected values of all threats and opportunities. An example of this process is presented on the Exhibit 20.

TYPE	PROBA-BILITY	PROXI-MITY	IMPACT TIME	IMPACT COST	IMPACT QUALITY	IMPACT SAFETY AND SECURITY	OTHER IMPACTS	TOTAL IMPACT	EXPECTED VALUE
Threat	**1**	**3**	**2**	**1**	**1**	**1**	**4**	**2,31**	**(2,31)**
Threat	**2**	**4**	**4**	**3**	**3**	**4**	**3**	**3,54**	**(7,07)**
Threat	**2**	**3**	**5**	**4**	**4**	**5**	**1**	**3,92**	**(7,83)**
Opportunity	**3**	**2**	**4**	**3**	**5**	**4**	**2**	**3,51**	**10,54**
Opportunity	**4**	**1**	**3**	**2**	**4**	**3**	**2**	**2,68**	**10,71**
Threat	**5**	**2**	**2**	**1**	**3**	**1**	**1**	**1,83**	**(9,13)**
								Total Risk Expected Value	**(5,10)**

Exhibit 20 – Example of a project expected risk value considering opportunities and threats.

The results from the process will be always a number between 1 and 25. In the example of Exhibit 20, the value -5,10 is equivalent to 20,4% negative exposure (5,10/25) for the Project.

Based on this result and the tolerance thresholds (HILSON & MURRAY-WEBSTER, 2007), the total exposure can be compared with other projects and the corporate limits to define potential risk response plans.

Conclusions

The qualitative risk method is always a simplified model if compared with the quantitative methods. The approach of this paper suggests an alternative model that can be tailored to include different kinds of impacts and scales in order to produce a reliable quantitative result.

This result allows opportunities and threats to be compared in order to determine the total risk exposure. The concept that an opportunity can cancel a threat of the same level is not possible with the traditional qualitative risk management approach.

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RICARDO VARGAS

DETERMINING THE MATHEMATICAL ROI OF A PROJECT MANAGEMENT IMPLEMENTATION

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New Orleans – Louisiana – USA – 2013

PMO Summit Brazil
Rio de Janeiro – RJ – Brazil – 2012

Abstract

Related Podcasts

♫ Calculating the Return on Investment of the PMO – Part 1/2
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♫ Calculating the Return on Investment of the PMO – Part 2/2
http://rvarg.as/2v

♫ *The Cost of Project Management*
http://rvarg.as/bg

♫ *The cost of Project Management and the PMO*
http://rvarg.as/bj

The objective of this paper is to present, discuss and apply a mathematical model based on the use of Monte Carlo simulation in conjunction with researches on project success/failure rates of projects to develop a 10 step model to calculate the mathematical return on investment (ROI) for the Project Office implementation.

The paper aims to provide guidance on how intangible results resulting from the project planning and control can be linked to potential savings in time and cost comparing with projects poorly managed (KWAK & IBBS, 2000). It is not the scope of this paper to demonstrate the positive impact of good project management practices. The main objective is to discuss possible ways of measuring results in order to have a more clear cost benefit analysis regarding the value of a PMO Setup (HUBBARD, 2010).

This paper also discusses the main challenges to quantify benefits considering cultural, social and value perception dimensions in order to translate benefits into clear and measurable numbers.

The Importance of Clear Benefit Measurement

Business improvement processes like the Project Management Office implementation are, most of the time, linked to indirect benefits achievement. In the past, program, project, or process success was measured by activity: number of people involved, money spent, days to complete. Little consideration was given to the benefits derived from these activities because they were considered impossible to be clearly measured (PHILIPS & PHILIPS, 2007).

The intention of clear measurement of benefits can be based in the following arguments:

- Price/money is a proxy for value.
- Measurable outcomes contribute to a better alignment and integration with financial systems performance.
- More tangible results support the identification of critical sources of value.
- Promotes communication and makes results quantitatively tangible.

Understand the clear impact on project results of the project management processes, tools and existing support and how this structure contributes to better project results became a key driver to understand the value of project management (EIU, 2009)

Model Overview

The proposed model is based on 10 (ten) processes that are organized into 6 (six) groups (Exhibit 01). Both the processes and the groups are interrelated in order to produce the needed steps to understand the real costs and benefits brought by the Project Management Implementation.

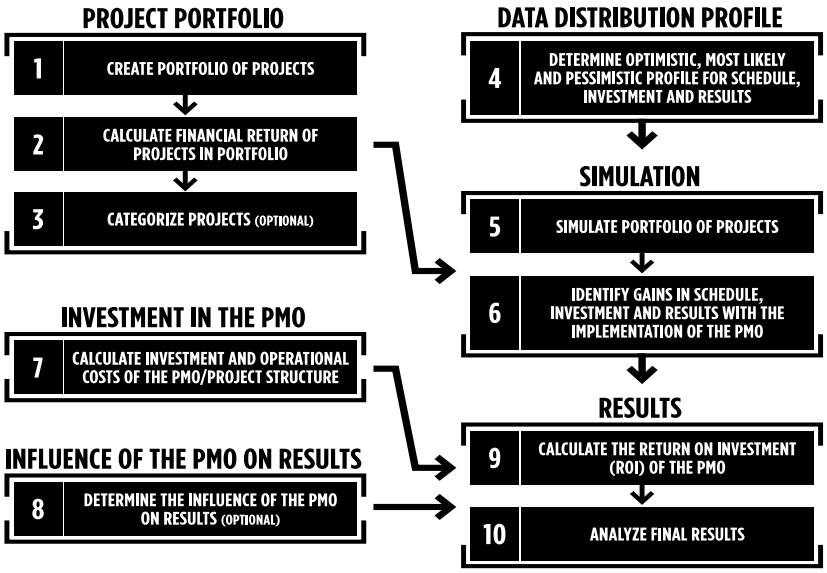


Exhibit 1 – 10 Processes to calculate the Return on Investment of a Project Management Office.

The processes are defined following the structure proposed by the PMBOK Guide (PMI, 2013) with Inputs, Tools and Techniques and Outputs.

Project Portfolio

The Project Portfolio group describes the process that should be in place to understand the scope of what should be managed by a potential Project Management Office (PMO). The intend is to make sure that the potential projects that will be supported by the project management office are identified and the cost, time frame and benefits (value) of these projects are calculated.

The Project Portfolio group is divided in the following processes

- Create the portfolio of projects
- Calculate financial return of projects in the portfolio
- Categorize projects

Create the Portfolio of Projects

This is process is responsible for the creation of the portfolio of projects. Based in working groups and the support of experts, it aims to create a list of the projects that will be managed by the PMO including some preliminary information like the Project objectives, estimated duration and budget (Exhibit 2).

1	CREATE PORTFOLIO OF PROJECTS	
INPUTS	**TOOLS AND TECHNIQUES**	**OUTPUTS**
1. Potential Projects	1. Working Groups 2. Expert Judgment	1. Project Portfolio 2. Preliminary Project Information (Objectives, Schedule and Budget)

Exhibit 2 – Create Portfolio of Projects

The Project Portfolio can be presented in different ways but the most suitable to support the upcoming process is a list with the name of the project, estimated duration and budget (Exhibit 3). If the Project Office will support all kinds of projects at the corporate level, the list of projects can include a very different set of initiatives.

ID	PROJECT	DURATION	BUDGET
1	Review of Product Mix	6	460,000
2	Zero Accidents	12	300,000
3	Internationalization of Production Units	23	6,350,000
4	Modernization of the Instrumentation System	8	2,420,000
5	E-commerce	4	350,000
6	Corporate Office Projects	7	450,000
7	New Markets	13	360,000
8	University Tiger Screws	7	350,000
9	New Line for the Oil Industry	18	2,850,000
10	New Distribution Center	19	3,600,000
11	Import Finished Products	22	2,080,000
12	Opening of Capital	24	1,200,000
13	Social Media	5	225,000
14	ERP System	9	1,240,000
15	New Maintenance Policy	17	680,000
	Total	**194**	**22,915,000**

Exhibit 3 – Example of basic project list

The preliminary project information can include all supporting information about the project, including main objectives, outputs, expected benefits and basic scope (Exhibit 4). This preliminary information can be also called Project Brief or Outline Business Case (UK CABINET OFFICE, 2011)

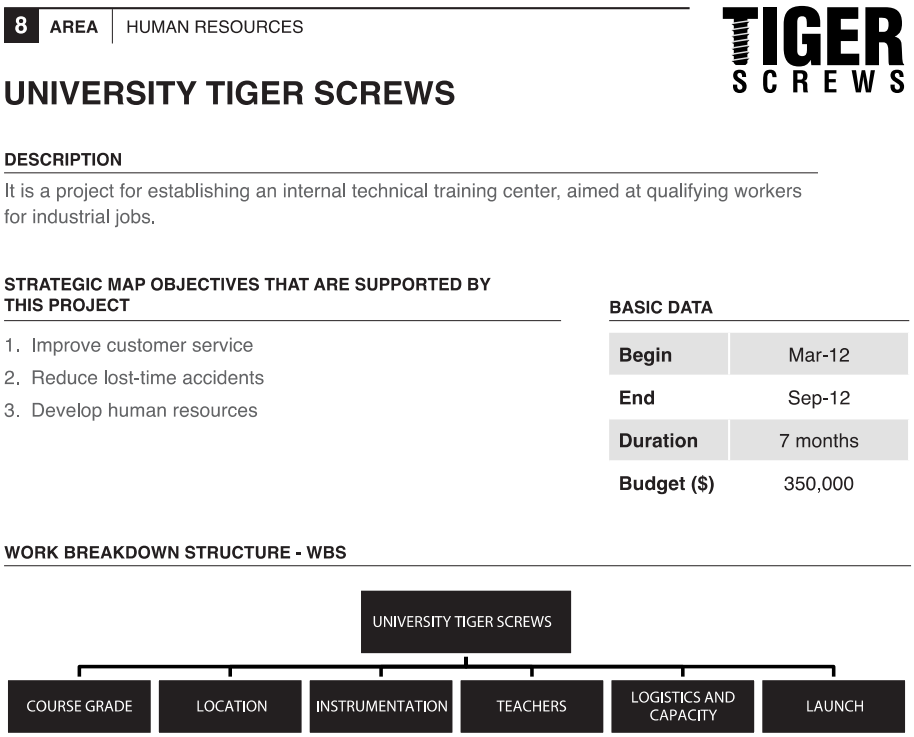


Exhibit 4 – Example of project preliminary information

Calculate Financial Return of Projects in the Portfolio

After identifying the potential portfolio of projects to be managed, it becomes important to calculate the benefits in terms of financial results of each project. This is one of the most challenging steps towards the calculation of the ROI of a Project office. Using the preliminary information, all proposed benefits will be measured in order to find clear outcomes (Exhibit 5).

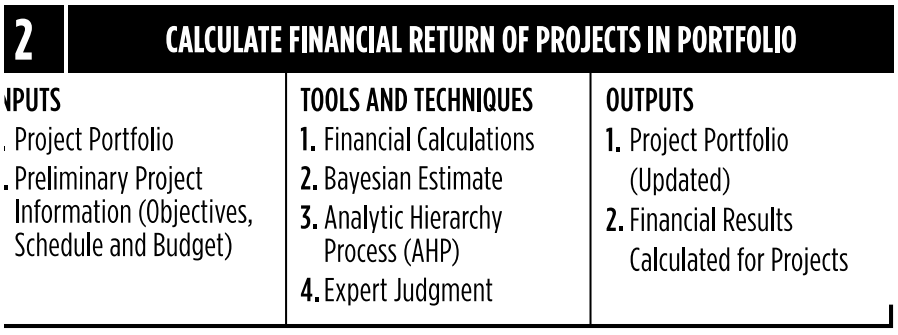
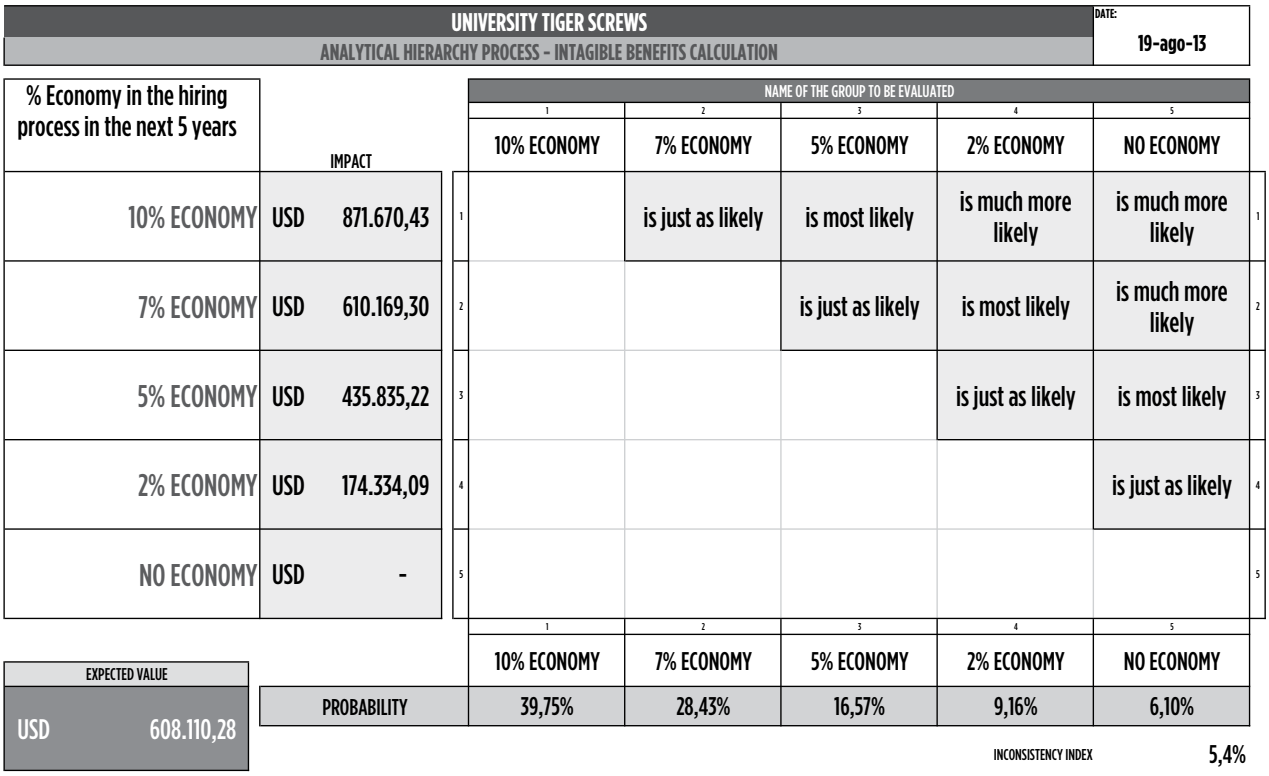


Exhibit 5 – Calculate Financial Return of Projects in the Portfolio

In some cases, this is easily measurable in terms of increase in the production, market place, etc. In other projects, the intangible results must be converted into an estimated final outcome. As an example, one main outcome of the "University Tiger Screws" project is to develop new capabilities in the current staff in order to reduce the investments with additional hiring of personnel. A range of potential

savings is defined and through the pairwise comparison using the Analytic Hierarchy Process (SAATY, 1980, SAATY, 2009 and VARGAS, 2010), the Expected Value of the benefit could be estimated (Exhibit 6).



UNIVERSITY TIGER SCREWS							DATE:
ANALYTICAL HIERARCHY PROCESS - INTAGIBLE BENEFITS CALCULATION							19-ago-13
% Economy in the hiring process in the next 5 years			NAME OF THE GROUP TO BE EVALUATED				
			1	2	3	4	5
	IMPACT		10% ECONOMY	7% ECONOMY	5% ECONOMY	2% ECONOMY	NO ECONOMY
10% ECONOMY	USD	871.670,43	1	is just as likely	is most likely	is much more likely	is much more likely
7% ECONOMY	USD	610.169,30	2		is just as likely	is most likely	is much more likely
5% ECONOMY	USD	435.835,22	3			is just as likely	is most likely
2% ECONOMY	USD	174.334,09	4				is just as likely
NO ECONOMY	USD	-	5				
			1	2	3	4	5
			10% ECONOMY	7% ECONOMY	5% ECONOMY	2% ECONOMY	NO ECONOMY
EXPECTED VALUE			PROBABILITY	39,75%	28,43%	16,57%	9,16%	6,10%
USD	608.110,28					INCONSISTENCY INDEX	5,4%

Exhibit 6 – Example of the use of AHP to estimate the Expected Value of the benefit of a project

The main output of this project is an updated list of projects including the estimated financial benefits.

Categorize Projects (Optional)

For organizations with a wide range of projects, the categorization of projects could add value in the analysis and stratification of efforts (Exhibit 7).

This optional process group the projects into different categories (Exhibit 8) like

- Departments
- Risk
- Value
- Sponsoring group
- Geographic location

3	CATEGORIZE PROJECTS (OPTIONAL)	
INPUTS	**TOOLS AND TECHNIQUES**	**OUTPUTS**
1. Project Portfolio	1. Description of the Categories 2. Working Groups 3. Expert Judgment	1. Projects Grouped in "Categories"

Exhibit 7 – Categorize Projects

ID	PROJECT	DURATION	BUDGET	FIN. RESUL. ($)	ROI	AREA	RISK	COMPLEXITY
1	Review of Product Mix	6	460,000	128,800	28%	Marketing and Sales	High	High
2	Zero Accidents	12	300,000	123,000	41%	Industrial	Low	Medium
3	Internationalization of Production Units	23	6,350,000	11,430,000	180%	Planning	Very High	High
4	Modernization of the Instrumentation System	8	2,420,000	1,573,000	65%	Industrial	Medium	Medium
5	E-commerce	4	350,000	126,000	36%	Information Technology	Medium	Medium
6	Corporate Office Projects	7	450,000	364,500	81%	Planning	Low	Low
7	New Markets	13	360,000	248,400	69%	Marketing and Sales	High	High
8	University Tiger Screws	7	350,000	258,110	74%	Human Resources	Low	Low
9	New Line for the Oil Industry	18	2,850,000	598,500	21%	Research and Development	High	High
10	New Distribution Center	19	3,600,000	2,124,000	59%	Logistics	Very High	High
11	Import Finished Products	22	2,080,000	4,430,400	213%	Marketing and Sales	Very High	High
12	Opening of Capital	24	1,200,000	660,000	55%	Financial	High	High
13	Social Media	5	225,000	41,116	18%	Marketing and Sales	Very Low	None
14	ERP System	9	1,240,000	347,200	28%	Information Technology	High	High
15	New Maintenance Policy	17	680,000	95,200	14%	Industrial	Medium	Medium
	Total	**194**	**22,915,000**	**22,548,226**				

Exhibit 8 – Example of a categorized list of projects with the calculated benefits highlighted

Data Distribution Profile

The Data Distribution Profile aims to determine the best "risk profile" of the portfolio to archive the benefits and it contains the process Determine Optimistic, Most Likely and Pessimistic Profile for Schedule, Investments and Results.

Using market research, historical information from previous projects and benchmarking, the objective of this process is to define the optimistic, pessimistic and most likely scenarios for the duration, costs and financial results of each project (Exhibit 9).

4	DETERMINE OPTIMISTIC, MOST LIKELY AND PESSIMISTIC PROFILE FOR SCHEDULE, INVESTMENT AND RESULTS	
INPUTS	**TOOLS AND TECHNIQUES**	**OUTPUTS**
1. Market Research 2. Benchmark of Project Results 3. Historical Information	1. Working Groups 2. Negotiation 3. Expert Judgment	1. Probabilistic Distribution Profile for Schedule, Investment and Results

Exhibit 9 – Determine Optimistic, Most Likely and Pessimistic Profile for Schedule, Investment and Results

Different external sources can be used to support the decision as follows

- Standish Group Chaos Manifesto (STG, 2013)
- The IPA Institute Database of Capital Projects (IPA, 2013)
- PMI Pulse Report (PMI, 2013)
- Reports and researches from management consulting companies

This process requires a lot of negotiation to set the right thresholds for the project without being biased by individuals with over optimistic or over pessimistic behaviors.

The determination of the profiles can be done considering that the project duration, costs and financial results follow the same distribution (Exhibit 10) or a different set of distributions for each element.

	Without PMO			With PMO		
COMPLEXITY	OPTIMISTIC	MOST LIKELY	PESSIMISTIC	OPTIMISTIC	MOST LIKELY	PESSIMISTIC
High Complexity	+25%	+50%	+75%	+0%	+5%	+15%
Medium Complexity	+25%	+50%	+75%	+0%	+5%	+15%
Low Complexity	+15%	+30%	+45%	+0%	+5%	+15%
No Complexity	+10%	+20%	+30%	+0%	+5%	+15%

Exhibit 10 – Example of probabilistic forecasting based on project complexity level.

In this case, a high complexity project with a value of $1,000,000 will cost between $1,250,000 and 1,750,000 without PM support and $1,000,00 and 1,150,000 with proper PM support.

Simulation

The Simulation group describes the process associated with the Monte Carlo simulation of the duration of the projects in the portfolio, associated costs and financial results.

"Monte Carlo" was a nickname of a top-secret project related to the drawing and to the project of atomic weapons developed by the mathematician John von Neumann (POUNDSTONE, 1993). He discovered that a simple model of random samples could solve certain mathematical problems which couldn't be solved up to that moment.

The simulation refers, however, to a method by which the distribution of possible results is produced from successive recalculations of project data, allowing the development of multiple scenarios. In each one of the calculations, new random data is used to represent a repetitive and interactive process. The combination of all these results creates a probabilistic distribution of the results (Exhibit 11).

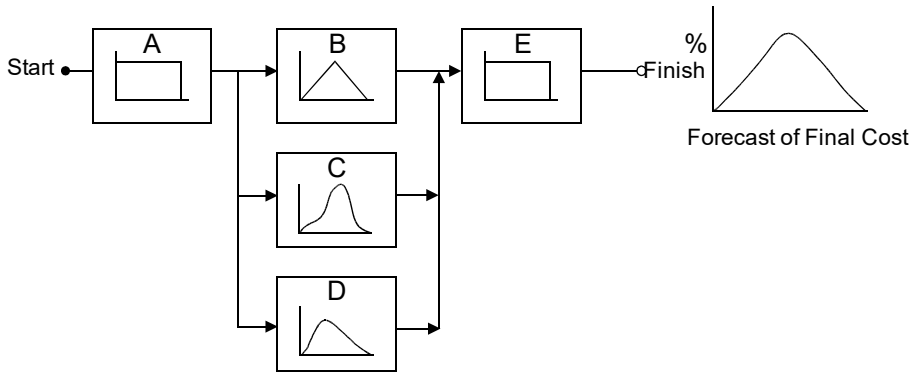


Exhibit 11 – Construction of model of distribution of costs and activities or work packages making up a final distribution from random data of the project (PRITCHARD, 2001).

The feasibility of outcoming distribution relies on the fact that, for a high number of repetitions, the model produced reflects the characteristics of the original distribution, transforming the distribution into a plausible result for analysis. The simulation can be applied in schedules, costs and other project indexes.

The Simulation group is divided in the following processes

- Simulate Portfolio of Projects
- Identify Gains in Schedule, Investment and Results with the Implementation of the PMO

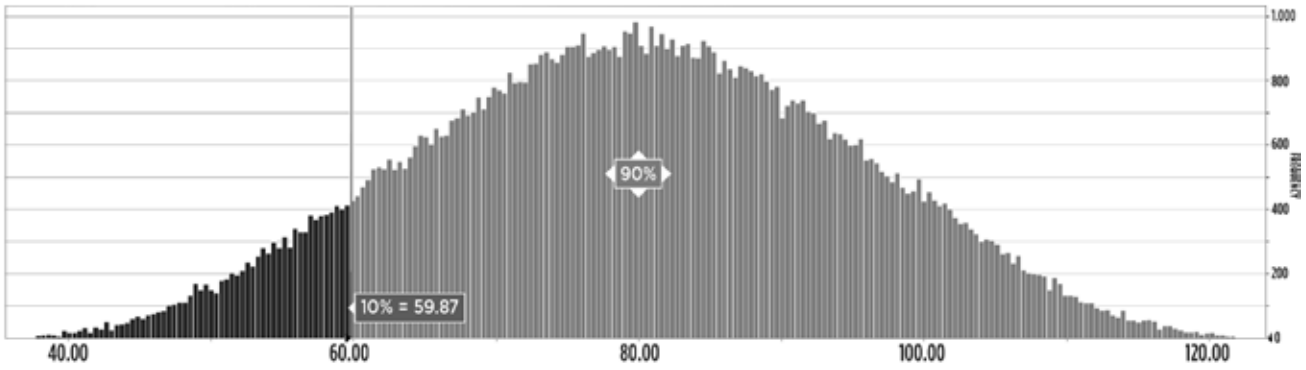
Simulate Portfolio of Projects

This is process is responsible for the simulation of the schedule gains, investment savings and improvements of financial results (Exhibit 12).

5	SIMULATE PORTFOLIO OF PROJECTS	
INPUTS	**TOOLS AND TECHNIQUES**	**OUTPUTS**
1. Projects Grouped in Categories 2. Project Portfolio 3. Probabilistic Distribution Profile for Schedule, Investment and Results	1. Monte Carlo Software Simulation	1. Probabilistic Distribution of Schedule Gains 2. Probabilistic Distribution of Investment Savings 3. Probabilistic Distribution of Improvements of Financial Results

Exhibit 12 – Simulate Portfolio of Projects

The simulation is produced using simulation software and the results are a range of improvements in duration, budget and financial results with their respective confidence level (Exhibit 13, 14 and 15).



STATISTICS

Trials	100,000
Mean	79.77
Median	79.78
Standard Deviation	15.02

PERCENTILE

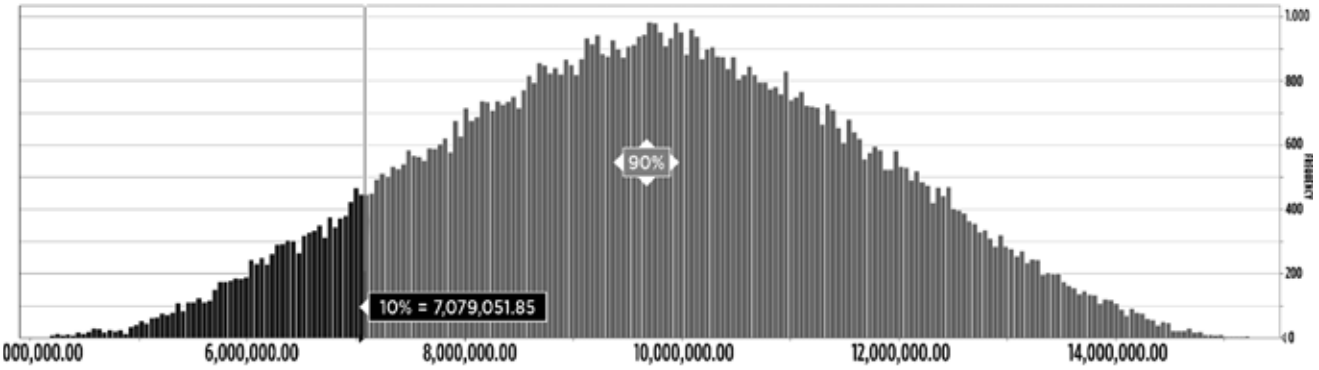
0%	31.29	60%	83.80
10%	59.87	70%	88.08
20%	66.53	80%	93.03
30%	71.52	90%	99.69
40%	75.77	100%	126.78
50%	79.78		

CONCLUSION

There is a 90% probability that the time gain using the PMO will be a minimum of **59.87 months**.

Please note that the objective of time gain is to evaluate the reduction in the projects' workload and not necessarily a faster completion of work.

Exhibit 13 – Example of simulation output for the savings in the total time of the projects for using the PMO. In this case there is a 90% confidence that the savings will be above 59,87 months.



STATISTICS

Trials	100,000
Mean	9,702,355.47
Median	9,710,732.45
Standard Deviation	1,974,491.61

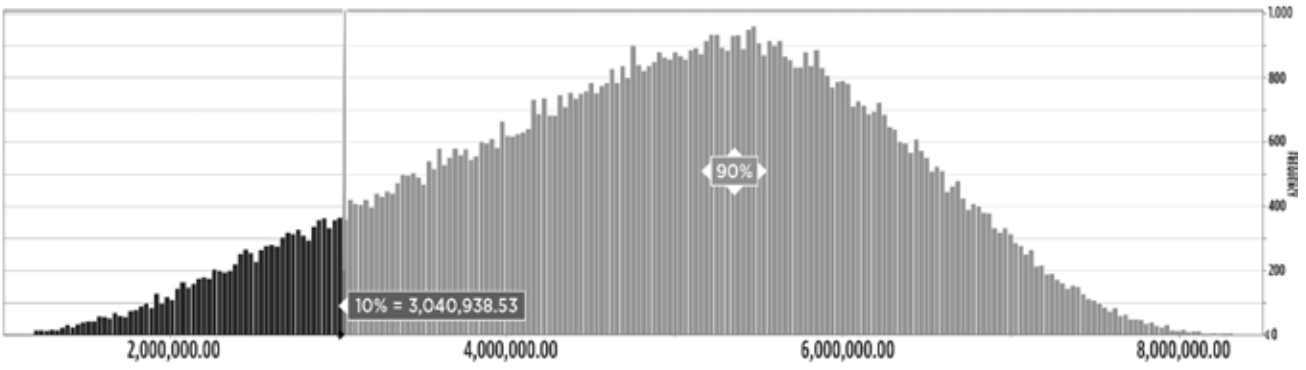
PERCENTILE

0%	3,606,978.10	60%	10,226,382.08
10%	7,079,051.85	70%	10,798,999.79
20%	7,949,33.15	80%	11,453,496.87
30%	8,615,088.26	90%	12,322,497.62
40%	9,182,361.04	100%	15,765,007.69
50%	9,710,723.29		

CONCLUSION

There is a 90% probability that **savings in financial investments** (budgets) using the PMO will be at least **$7,079,051.85**.

Exhibit 14 – Example of simulation output for the savings in the budget of the projects for using the PMO. In this case there is a 90% confidence that the savings will be at least 7,079,051.85 months.



STATISTICS

Trials	100,000
Mean	4,885,464.95
Median	4,990,530.57
Standard Deviation	1,318,293.80

PERCENTILE

0%	658,194.03	60%	5,338,818.99
10%	3,040,938.53	70%	5,679,229.44
20%	3,697,475.40	80%	6,058,075.00
30%	4,204,554.59	90%	6,544,955.20
40%	4,622,957.56	100%	8,315,454.74
50%	4,990,451.82		

CONCLUSION

There is a 90% probability that **the gains in financial results** with the use of the PMO will be at least **$3,040,938.53**.

Exhibit 15 – Example of simulation output for the gains in financial results of the projects for using the PMO. In this case there is a 90% confidence that the savings will be at least 3,040,938.53 months.

Identify Gains in Schedule, Investment and Results with the Implementation of the PMO

After the simulation is concluded, the results are collected for a predefined confidence level in order to identify the measurable improvements (Exhibit 16 and 17).

6	IDENTIFY GAINS IN SCHEDULE, INVESTMENT AND RESULTS WITH THE IMPLEMENTATION OF THE PMO	
INPUTS	**TOOLS AND TECHNIQUES**	**OUTPUTS**
1. Probabilistic Distribution of Schedule gains 2. Probabilistic Distribution of Investment saving 3. Probabilistic Distribution of Improvements of Financial Results 4. Organizational Tolerance Level	1. Negotiation 2. Expert Judgment	1. Schedule Gains 2. Savings on Investment 3. Improvement of Financial Results

Exhibit 16 – Identify Gains in Schedule, Investment and Results with the Implementation of the PMO

GAINS IN FINANCIAL RESULTS ($) Resulting from budget reduction and an improvement in the financial results.	10,119,990.38
FINANCIAL GAINS / PORTFOLIO VALUE (%)	44.16%
IMPROVEMENT IN TIME / EFFORT RELIABILITY OF 90%	59.87 months

Exhibit 17 – Example of gains based on the simulation results (Exhibit 13, 14 and 15)

Investments in the PMO

The other aspect that must be considered when evaluating the ROI of a project implementation is to calculate the amount of costs the organization will incur to create and maintain the Project Office.

Different costs can be associated with the PMO (AUBRY, HOBBS, MÜLLER & BLOMQUIST, 2010). The most common elements are

- Personal cost
- Software and hardware
- Advisory services
- Training
- Others

7	CALCULATE INVESTMENT AND OPERATIONAL COSTS OF THE PMO/PROJECT STRUCTURE	
INPUTS	**TOOLS AND TECHNIQUES**	**OUTPUTS**
1. Direct Costs 2. Indirect Costs 3. Investment in Consultancy 4. Investment in Training 5. Procurement 6. Other Information on Costs and Investment	1. Financial Calculations 2. Budget Structure 3. Negotiation 4. Expert Judgment	1. Structure of Investment/ Cost of the PMO

Exhibit 18 – Calculate Investment and Operational Costs of the PMO/Project Structure

The main output of this process is the total cost of the PMO setup and operation for a predefined time frame (Exhibit 19).

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	TOTAL	TOTAL PV
Infrastructure	50.000	50.00	20.000	30.000	50.000	200.000	161.368,16
Consulting	800.000					800.000	800.000,00
Personal	420.000	420.000	420.000	420.000	420.000	2.100.000	1.669.277,96
Equipment	100.000					100.000	100.000,00
Other	10.000	10.000	10.000	10.000	10.000	50.000	39.744,71
Total	**1.380.000**	**480.000**	**450.000**	**460.000**	**480.000**	**3.250.000**	**2.770.390,83**

Exhibit 19 – Example of a PMO Setup and operation cost in a 5 (five) year time frame. All values should be adjusted to Present Value

Influence of the PMO in the Results

Based on the studies discussed in the step 4 of the process, it is important to highlight that not all benefits and positive results exclusively stem from the very existence and operation of the PMO. Many other external factors can benefit from those results and are beyond the control of the project manager and his/her team.

Some examples of benefit / dis-benefit drivers not related to project management implementations are (UK CABINET OFFICE, 2011)

- External economic factors like currency exchange rate, interest rates
- Market changes
- Changes in the legislation
- Changes in the senior leadership
- Others

In this process (Exhibit 20), it is proposed the use of the Analytical Hierarchy Process (AHP) to compare the likelihood of benefits coming from the PMO, in comparison with other sources of benefits (SAATY, 1980 and VARGAS, 2010).

8	DETERMINE THE INFLUENCE OF THE PMO ON RESULTS (OPTIONAL)	
INPUTS	**TOOLS AND TECHNIQUES**	**OUTPUTS**
1. Success Factors 2. Failure Factors 3. Market Research 4. Benchmark of Project Results 5. Historical Information	1. Analytical Hierarchy Process (AHP) 2. Expert Judgment	1. Percentage of Results Attributable to the PMO

Exhibit 20 – Determine the Influence of the PMO on Results

The output of this process is the weight of the PMO in relationship with other sources of benefits (Exhibit 21).

		1	2	3	4	5	
		MARKET CHANGES	LEGISLATION	PROJECT MANAGEMENT (PMO)	LOW TECHNICAL SKILLS	OTHERS	
MARKET CHANGES	1		Likely	Less likely	Very likely	Likely	1
LEGISLATION	2			Very unlikely	Very likely	As likely as	2
PROJECT MANAGEMENT (PMO)	3				Highly likely	Very likely	3
LOW TECHNICAL SKILLS	4					Less likely	4
OTHERS	5						5
		1	2	3	4	5	
INCONSISTENCY INDEX: 6,8%		MARKET CHANGES	LEGISLATION	PROJECT MANAGEMENT (PMO)	LOW TECHNICAL SKILLS	OTHERS	
PROBABILITY		23,36%	11,61%	52,20%	3,63%	9,21%	

Exhibit 21 – Example of AHP comparing different sources of benefits with project management implementation. In this case, it is suggested that 52,2% of the benefits could be justified by the setup and operations of a PMO

Results

The final group of process intends to calculate the return on investment and also analyze and discuss the final results.

The Results group is divided in the following processes

- **Calculate the Return on Investment (ROI) of the PMO**
- **Analyze Final Results**

Calculate the Return on Investment (ROI) of the PMO

This process compare the results obtained in the simulation and compare them with the investments related to the PMO and the percentage of results attributable to the PMO (Exhibit 22).

9	CALCULATE THE RETURN ON INVESTMENT (ROI) OF THE PMO	
INPUTS	**TOOLS AND TECHNIQUES**	**OUTPUTS**
1. Schedule Gains 2. Savings on Investment 3. Improvement of Financial Results 4. Structure of Investment/ Cost of the PMO 5. Percentage of Results Attributable to the PMO	1. Financial Calculations	1. Return on Investment (ROI) of the PMO 2. Complementary Information 3. Calculation Report 4. Final ROI Report

Exhibit 22 – Calculate the Return on Investment (ROI) of the PMO

The output of this process is the calculated return on investment with complementary information (Exhibit 23).

GAINS IN FINANCIAL RESULTS ($) Resulting from budget reduction and an improvement in the financial results.	10,119,990.38
FINANCIAL GAINS / PORTFOLIO VALUE (%)	44.16%
IMPROVEMENT IN TIME / EFFORT RELIABILITY OF 90%	59.87 months
IMPORTANCE OF THE PMO ON RESULTS (%)	52.20%
FINANCIAL GAINS ADJUSTED FOR IMPORTANCE OF THE PMO ON RESULTS ($)	5,282,634.98
PMO INVESTMENT ($)	2,770,390.83
PMO RETURN ON INVESTMENT ($)	**2,512,244.15**
PMO RETURN ON INVESTMENT (%)	**90.68%**

Exhibit 23 – Example of financial calculation based on the simulation results and the cost / relevance of the PMO in the results.

Analyze Final Results

After receiving the final ROI Report, working groups and the PMO sponsoring group need to meet in order to analyze and discuss the results to make the final decision (Exhibit 24).

10	ANALYZE FINAL RESULTS	
INPUTS	TOOLS AND TECHNIQUES	OUTPUTS
1. Final ROI Report	1. Working Groups 2. Negotiation	1. Decision Making 2. Lessons Learned 3. Agreement on Results

Exhibit 24 – Analyze Final Results

Conclusions

The proposed model is a "master line" of the value calculation and can thus be customized and adapted to different scenarios. It is important to highlight that this model is a simplification of very complex environment, where different perceived values can provide different directions to different stakeholders.

In order to avoid resistance and criticism during the simulation of intangible results, it is important to do this work in teams to avoid personal biases in the process.

Finally, it important to understand the challenge of determining ROI without knowing which projects are selected and the strategy that supports them. A project office that takes care of several different multi million projects is a very different effort from a project office that has simple work packages to be controlled.

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RICARDO VARGAS

The Sustainability Marker to Support the Project Selection Process: The Unops Case

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Abstract

The objective of this paper is to present a non conventional approach that is being currently implemented at the United Nations Office for Project Services (UNOPS), when selecting new projects globally, in order to include, as project selection criteria, social, environmental and economic sustainability aspects in humanitarian and development projects.

Using a set of twenty five themes in four major groups, an internal tool called Sustainability Marker was developed to analyse projects above and beyond the traditional financial criteria in order to evaluate the real impact of the project to the sustainable development goals.

Related Podcasts

♫ Understanding the Rolling Wave Planning
http://rvarg.as/6z

♫ When Much sometimes is Too Much
http://rvarg.as/bn

♫ Understanding the Effort Driven Task in a Project
http://rvarg.as/am

♫ Using Generic Resources in the Resource Allocation
http://rvarg.as/3e

Traditional Project Evaluation Criteria

When looking into how organizations decide over which projects to execute, we can notice a constant desire to have clear, objective and mathematical criteria (HAAS & MEIXNER, 2005). However, decision making is, in its totality, a cognitive and mental process derived from the most possible adequate selection based on tangible and intangible criteria (SAATY, 2009), which are arbitrarily chosen by those who make the decisions.

Basically, the prioritization of projects in a portfolio is nothing more than an a sequencing scheme based on a benefit cost relationship for each project. Projects with higher benefits, when compared to their costs, will have a higher priority. It's important to observe that a benefit cost relationship does not necessarily mean the use of exclusive financial criteria like the widely known benefit cost ratio, but instead a broader concept of the reaped benefits from executing the project and their related efforts (VARGAS, 2010).

In most enterprises, the main criteria groups are related to financial, strategic, risks, urgency and stakeholder commitment aspects (VARGAS, 2010). The main challenge is to put in place criteria that can capture outcomes instead of just basic outputs. Many real cases support the lack of understanding of the real expected outcomes, where projects were delivered to time, cost and quality objectives and yet are not yielding positive results (DUGAL, 2010). Project managers have constructed bridges without access roads, have built hospitals and courthouses which are empty later on, have implemented ERP systems and other business changes that have destroyed organizations[1].

[1]See Catalog of Catastrophe at *http://calleam.com/WTPF/?page_id=3*

PMI's Standard for Portfolio Management (PMI, 2012) mentions that the scope of a project portfolio must stem from the strategic objectives of the organization. These objectives must be aligned with the business scenario which in turn may be different for each organization. Consequently, there is no perfect model that covers the right criteria to be used for any type of organization when prioritizing and selecting its projects. The criteria to be used by the organization should be based on the values and preferences of its decision makers.

UNOPS Sustainability Criteria

With a strong focus on the developing world, United Nations Office for Project Services (UNOPS) states that a project can only be considered sustainable if it address the impacts on a broader set of stakeholders, including generations not yet born (BOBROW, 2014). This comprises sustainability aspects that should be embedded into the project while executing it (*How*) and the sustainability aspects after its conclusion (*Aim*).

AIM	HOW
Projects and programmes comply to strict criteria concerning environmental and social scope and planned results before they are initiated.	UNOPS teams embed cross-cutting initiatives, such as how to get the best community support, into their project planning and implementation phases.

Exhibit 1 – UNOPS definition of a sustainable project

Insert sustainable principles into every single project is a major task and sometimes the decision on what actions should be in place create a dilemma for the project manager and the project team. In the locations where UNOPS operates, funding is often too limited to address all of the basic needs. Let's take the example of building a school. There can be enough funding to put solar panels on the roof or to build more class room space but not both. If we put the panels on then the school can have electricity and provide space for computers and potentially evening classes. However, if instead the classroom is made larger, more children can attend. How should a project manager make such a decision? (BOBROW, 2014).

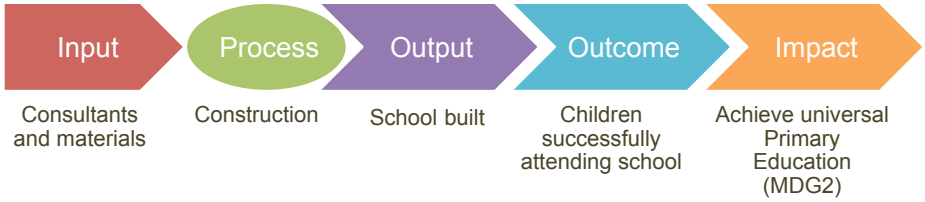

Exhibit 2 – Example of transforming Inputs in to outputs, outcomes and impact in the development sector (UNOPS, 2014)

In order to support an informed decision making process, four categories of sustainability were identified based on the Aspire Model with some adaptation to the development context:

- **Social** – It covers aspects such as gender, population, vulnerability and other aspects related to the community where the project is being implemented.
- **Environmental** – It covers aspects such as air, land, water and biodiversity where the project is being implemented.
- **Economic** – It covers aspects such as the economic relevance for the community, job generation, equity and livelihood.
- **National Capacity** – It covers aspects such as the use of local capacity to deploy the project including skills and knowledge, corruption, political and social stability.

25 Themes of the Sustainability Marker

After discussions with partners, project managers and experts in the field, the 20 themes within the ASPIRE model were adapted and augmented into the 25 themes now represented in the UNOPS Sustainability Marker. (Exhibits 3, 4, 5 and 6).

	THEMES	#	QUESTIONS	CONSIDERATIONS
SOCIAL	**Populations**	1	What is the likely effect of the project on local communities?	Population change Community cohesion Conflict sensitivity Displacement Population density affecting environmental sustainability Population movement and traffic
	Cultures	2	What is the likely effect of the project in terms of community culture and identity?	Socio-cultural identity Cultural and religious facilities Main stakeholder's heritage and archaeology Use of environment Intergenerational practices
	Services	3	What is the likely effect of the project on access to essential services?	Energy Mobility & transport Road construction Telecommunications Education Communal space Crime, Security, Police, Fire and Ambulance services
	Health	4	What is the likely effect of the project in relation to the public health infrastructure and services?	Sanitation Solid waste Drainage Healthcare Shelter Nutrition HIV/AIDS and other communicable diseases
	Vulnerability	5	What is the likely effect of the project on community institutions and social networks?	Community cohesion Vulnerable groups Indigenous groups Minority groups People with disabilities
	Resilience	6	What is the likely effect of the project in terms of resilience of communities to shocks, stresses and hazards?	Ability to resist and recover in a timely and efficient manner Physical infrastructure Livelihood diversification Access to finance and insurance
	Gender	7	What is the likely effect of the project on gender equality or female empowerment?	Differential effect on men and women Access for women

Exhibit 3 – Social themes

	THEMES	#	QUESTIONS	CONSIDERATIONS
ECONOMIC	**Viability**	17	What will be the likely effect on the project after external funding and UNOPS involvement are withdrawn?	Value for money Risk management Carbon pricing Operation and maintenance Alignment with national/regional strategies Appropriate technologies Functionality for the full planned life span
	Macro	18	What is the likely effect of the project on the vitality of the local economy?	Vitality and regeneration Value added/multiplier effects Debt Inflation effects Ethical competition
	Livelihoods	19	What is the likely effect of the project on employment and livelihood opportunities of the project-affected communities?	Local sourcing Access to finance Distortions to local economy Employment creation Labor standards Training
	Equity	20	Will the benefits of the project be equally accessible to all members of society? If yes, indicate a positive effect. If no, indicate a negative effect.	Equal opportunities Affordability of services Debt Land tenure Communication about the project

Exhibit 4 – Economic themes

	THEMES	#	QUESTIONS	CONSIDERATIONS
ENVIRONMENTAL	**Air**	8	What is the likely effect of the project on local air quality?	Ambient air quality Direct emissions Dust and particulates Ozone depleters
	Land	9	What is the likely significant effect of the project on land resources and land usage?	Site location Planning intent Diversity/mixed use Contaminated land Soil conservation”
	Water	10	What is the likely effect on surface, groundwater or coastal waters?	Drainage systems Water pollution Sewage treatment and disposal Water availability Water efficiency “
	Biodiversity	11	What is the likely effect of the project on natural ecosystems?	Protected areas Nature conservation Ecosystems Environmental risk management
	Energy	12	What is the likely effect on shared / municipal energy supplies?	Energy efficiency
	Materials - Lifecycle	13	What is the likely effect on the ecosystems and communities from the materials used throughout the life of the project or asset?	Whole life analysis Local sourced materials Recyclability
	Materials - Waste	14	What is the likely effect of project ‘waste’ on the ecosystems and communities?	Shared / municipal waste disposal facilities Volume of solid waste Toxic or hazardous waste
	Global Climate	15	What is the likely effect of the project on greenhouse gas emissions?	Net reduction or net increase in greenhouse gas emissions
	Disaster Risk Reduction	16	What is the likely effect of the project on the risk environment?	Reduction or increase in risk posed by floods, droughts, landslides, due to construction

Exhibit 5 – Environmental themes

	THEMES	#	QUESTIONS	CONSIDERATIONS
NATIONAL CAPACITY	**Structures - Institutions**	21	What is the likely effect of the project on institutional civil structures?	National/local government effectiveness Effective delivery of services Capacity to run/ maintain the project/ services after handover? Project - Government coordination
	Structures - Corruption	22	Will this project have effect on corruption within institutions (private sector / government / civil society)?	Corruption Civil society Rule of law
	Skills & Capacity Development	23	What is the likely effect of the project on the skills and capacity of local / national private sector / government / civil society to undertake similar projects in the future?	Research and innovation Local supply chains Information disclosure and reporting Monitoring and evaluation Media channels Knowledge exchange
	Political	24	What is the likely effect of the project on political stability or security?	Stability of national governments Effect on areas of conflict Political ramifications
	Policies	25	What is the likely effect of the project in terms of alignment with local policy and regulatory frameworks or international as appropriate?	Regulatory quality Human rights Health and safety Quality assurance Intellectual property rights

Exhibit 6 – National Capacity themes

Evaluating the Sustainability Themes

UNOPS project life cycle follows a five stage process (UNOPS, 2014) as presented in the Exhibit 7.

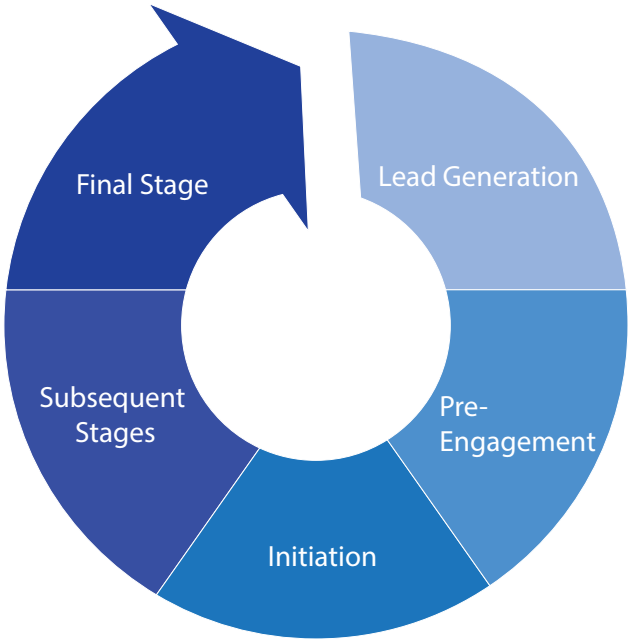

Exhibit 7 – UNOPS Engagement Process (UNOPS, 2014)

The Engagement process steps follow a progressive development where more effort is put in place during the initial phases, in order to collaborate with the project's key stakeholders to adjust the plans and outputs to address the relevant sustainability aspects. This approach follows the concept that the capability to add value decreases and the cost of correction increases exponentially over time for an given project (VARGAS, 2014).

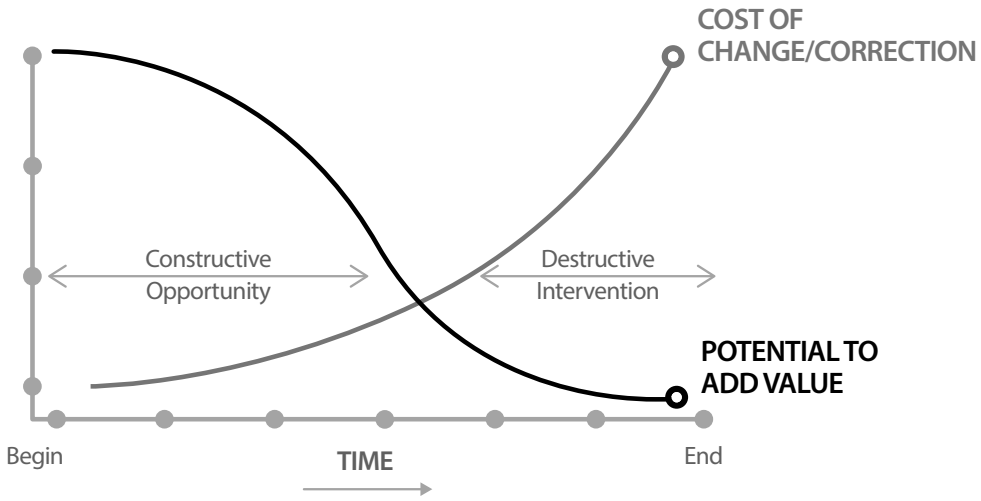

Exhibit 8 – Potential to add value again the cost of correction for an specific project (VARGAS, 2014)

On the Lead Generation phase, a bigger effort is put into place to work with the key stakeholders on the relevance of each sustainability aspect.

During this stage, training, discussion forums and informal assessments are put in place to create the positive environment for the Pre-Engagement phase assessment.

On the Pre-Engagement phase, the team needs to assess the twenty five themes for the project delivery (effects during project delivery) and for the post-project (effects after the outcome has been delivered). The effect-based scale is presented on the Exhibit 9.

Exhibit 9 – Effect based scale on the Pre-Engagement Phase (during and after project delivery)

After consolidating the information, the marker chart is presented for both Post-project and During Delivery scenarios (Exhibit 10).

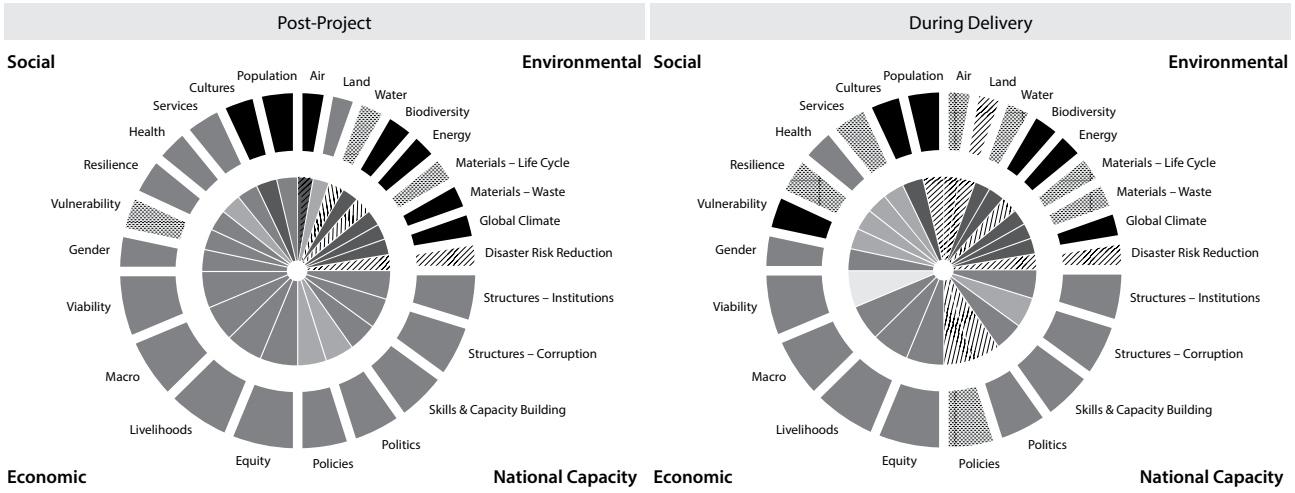

Exhibit 10 – Example of Sustainability Marker Wheel Graph during the Pre-Engagement phase

After the Pre-engagement phase, the project team will work with the stakeholders to address any relevant sustainability aspects through direct actions in the project delivery or changes to the scope statement and scope definition (PMI, 2013a) to include specific activities, potential budget lines or a direct benefit of the project, if applicable (Exhibit 11).

Exhibit 11 – Action plan scale on the Initiation Phase

The final result depicts an expected improvement to the sustainability aspects to be delivered by the project by the implemented actions, like it is presented in the Exhibit 12.

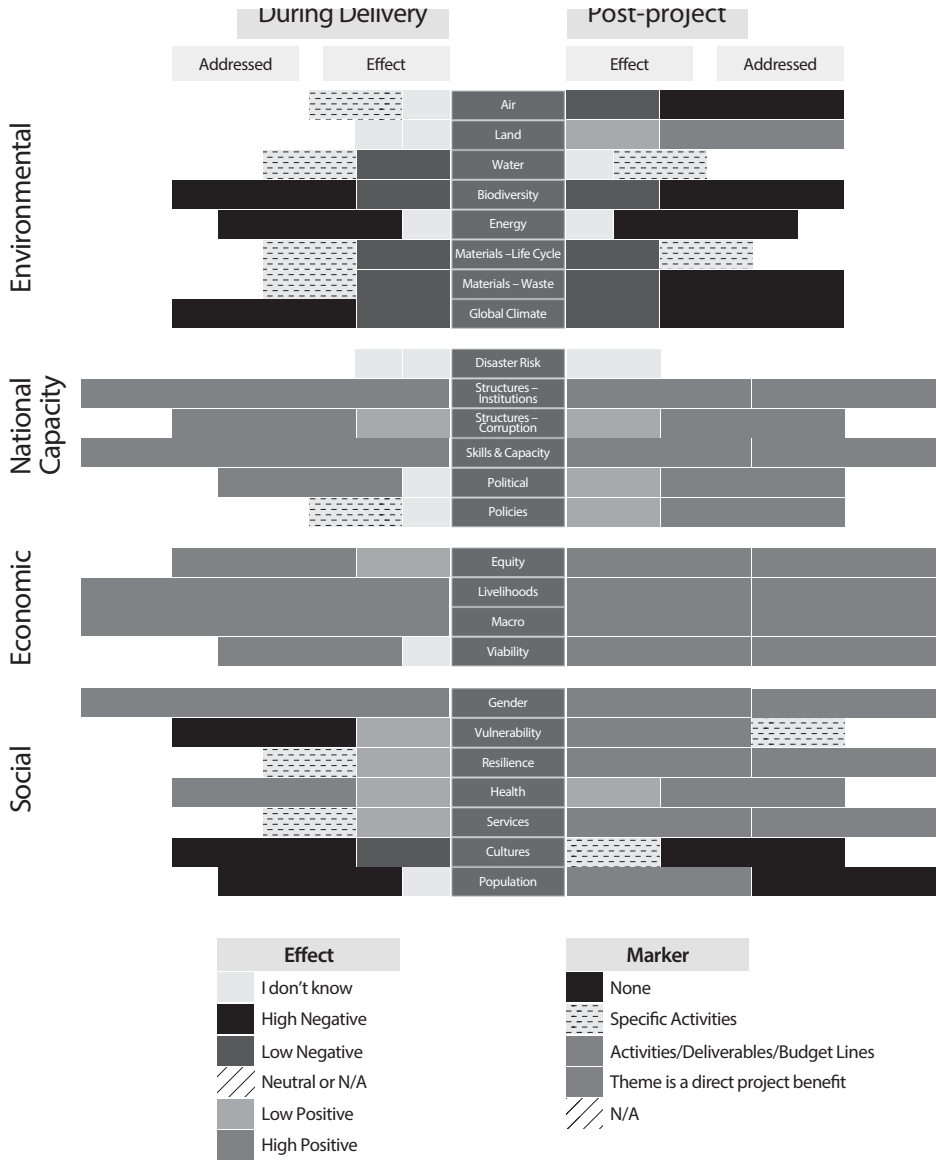

Exhibit 12 – Example of Sustainability Marker Bar Graph during the Initiation Phase (Including Action Plans)

Conclusions

This paper aimed to present and discuss the selection criteria implemented by UNOPS to address social, environmental and economic sustainability in human-

itarian and development projects by using twenty five themes grouped in four dimensions for the project execution and post-project results.

The UNOPS Sustainability Marker is currently on pilot in most of the 1,300 UNOPS projects globally. Challenges related to different cultural aspects, resistance to change and short term need x long term perspective have been addressed and incorporated on each new release of the tool.

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RICARDO VARGAS

USING EARNED VALUE MANAGEMENT INDEXES AS A TEAM DEVELOPMENT FACTOR AND A COMPENSATION TOOL

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PMI Global Congress 2004 - EMEA
Prague – Czech Republic – 2004

Abstract

The objective of this paper is to present the main components of the development of a project team, the motivational characteristics inherent to the team work and an interrelation proposal between the earned value analysis and team development through the SPI and CPI indexes obtained by the tool and team development models and the compensation and reward in the project, allowing to reduce the evaluation subjectiveness of the human resource in the project.

The paper presents a brief report about the team development and compensation policies, as well as an introduction to the earned value concept aiming to align the approached concepts.

Related Podcasts

♫ Demystifying the Portfolio Management – Part 1/3: The Strategy's Side
http://rvarg.as/1j

♫ Demystifying the Portfolio Management – Part 2/3: The Criteria
http://rvarg.as/1o

♫ Demystifying the Portfolio Management – Part 3/3: A comparison and Decision
http://rvarg.as/1s

♫ Why is so complex to be Simple and Effective during the Project Selection?
http://rvarg.as/6x

♫ Why is it So Hard to Define Clear Criteria for Selecting Projects?
http://rvarg.as/6c

Team Development in Projects

The project human resources area is one of the PMBOK Guide 2000 (PMI 2000) knowledge areas that the manager and project team have requested more attention.

As reported in the Guide, the Project Human Resources Management includes the processes required to make the most effective use of human resources involved with the project. It includes all project stakeholders: sponsors, customers, individual contributors and others. The main processes are described below and Exhibit 1 provides an overview of the processes according to each project phase.

Organizational Planning – identify, document and assign project roles, responsibilities and the reporting relationships.

Staff Acquisition – make the required human resources be designed and work in the project.

Team Development – develop individual and group skills to increase project performance.

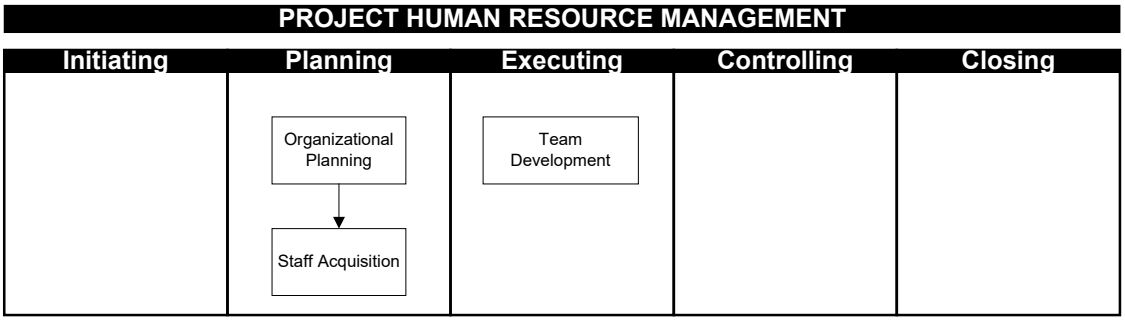

Exhibit 1 – Human Resources Management Processes distributed throughout the project phases.

These processes interact with each other and with the process in the other knowledge areas. Each process may involve effort from one or more individuals or groups depending on the needs of the project.

The team development approached in this paper involves the increase of the capability of the involved parties to contribute individually, as well as the increase of people capability to work as a team. The individual growth (managerial and technical) is the basis required to develop the team becoming it crucial to the success of the projects and, therefore, becoming the key for the organization to accomplish their goals.

According to FITZ-ENZ (2000), each organization and each project are led by a combination of strengths and internal and external factors. These factors are the

ones that make the organization unique, describing collectively how and why the organizational processes influence on the performance improvement. The internal factors are the ones determined by the own organization and project goals, while the external objectives are those determined by external business environment in which the company and projects are inserted (Exhibit 2).

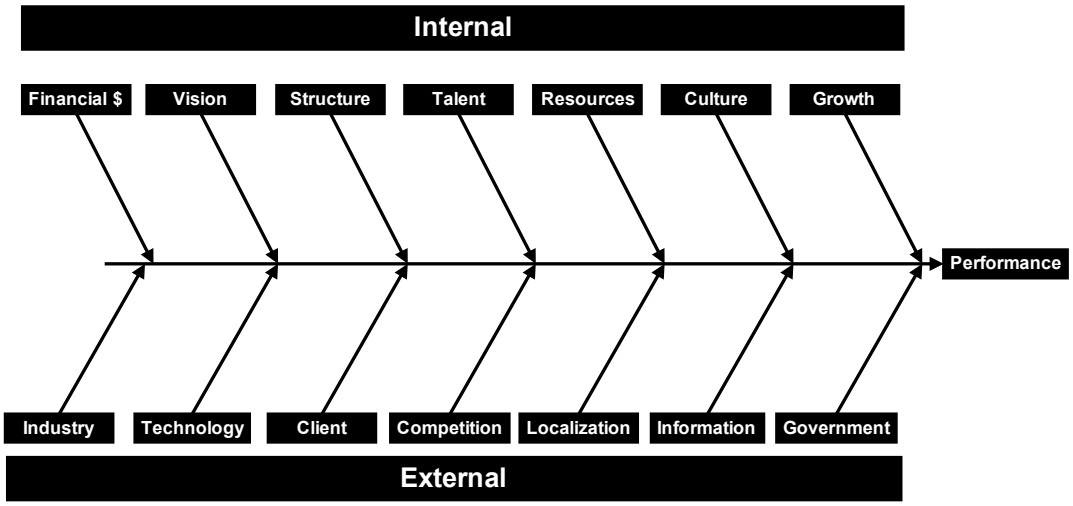

Exhibit 2 – Performance change factors

According to FLANES & LEVIN (2001) performance problems that impede the team members to perform their activities successfully can be divided in:

- Problems related to technical competency
- Problems related to relationship and communication
- Problems related to time management and work habits

Due to the above problems, it is fundamental to have an impartial and objective performance evaluation process that besides addressing the mentioned problems, it allows improvements in the individual skills, improvements in the team behavior and improvements not only in the individual competencies but also in the team ones.

This impartial model directly reduces the subjectiveness of the performance evaluation and increases the team motivation according to the Adam's Equity Theory (VERMA, 1995), as people get motivated when they are treated in equity, impartial and fair way.

Professional compensation (Reward)

Some of the main tools available to increase performance are the compensation and reward policies that according to PMI (2000) are the formal actions that promote or reinforce desired behavior. To be effective, such system should make the link between performance and reward clear, explicit and achievable.

According to PARKER, MCADAMS & ZIELINSKI (2000) the reward models are designed to create a focus on specific goals or celebrate and reward individuals or teams with diversified performance. To them, the reward models should meet individual, team and organization needs, according to the model showed in Exhibit 3.

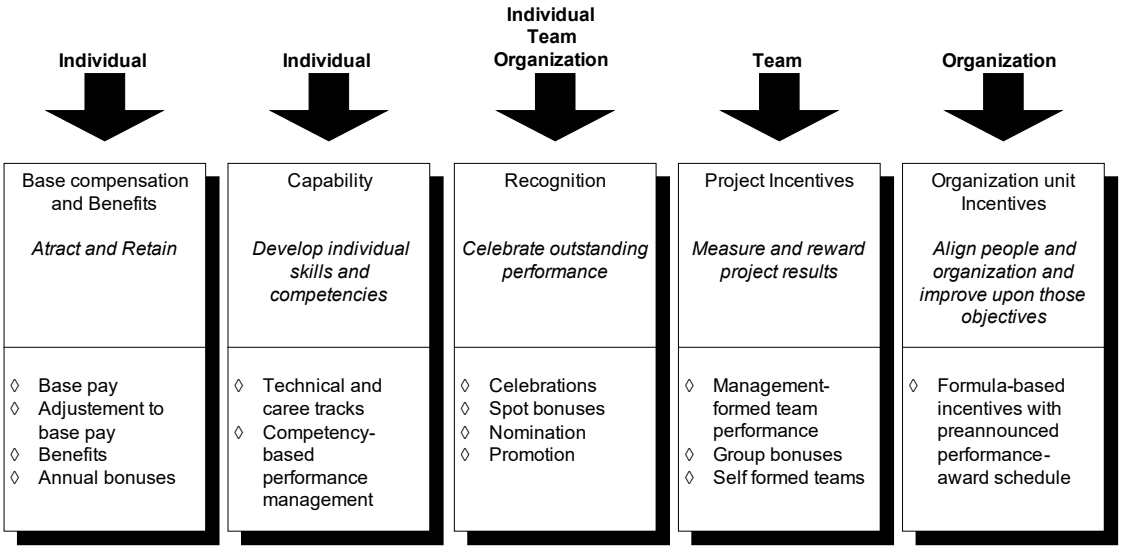

Exhibit 3 – Reward policies and bonuses (PARKER, MCADAMS e ZIELINSKI, 2000)

To SHUSTER (2000) the bonuses always need to satisfy the individual and the team. If a team satisfaction is neglected to satisfy an isolated individual, this process naturally generates dissatisfaction and demotivation. Thus, higher reward can only be gotten when high team and individual performances are achieved, as per Exhibit 4.

		INDIVIDUAL	
		Low Performance	**High Performance**
TEAM	**Low Performance**	◿ No individual compensation ◿ No team compensation	◿ Small individual compensation ◿ No team compensation
	High Performance	◿ No individual compensation ◿ Small team compensation	◿ Maxim individual compensation ◿ Maxim team compensation

Exhibit 4 – Team and individual performance extent (Based on Shuster, 2000)

Earned Value Analysis

Earned value is focused on the relation between incurred actual cots and the work performed in the project in a given time period. The focus is on performance obtained in comparison to what was spent to get it. (FLEMING & KOPPELMAN, 1999).

Earned value is the evaluation between what was actually spent and what was budgeted, proposing that the value to be earned initially by an activity is the value budgeted for it. As each activity or task of a project is performed, the initial budgeted value for the activity starts to constitute now the Earned Value of the project.

In order to formalize the mentioned concepts based on instruction DOD (1997) and on norm ANSI/EIA 748 of the American National Standards Institute, a specific terminology was created based on forecasted and actual costs, as well earned value. The basic three elements of the earned value analysis are:

BCWS (Budget cost of work scheduled) is the value that indicates the budget portion that should be spent, taking into account the activity budget base line cost, allocation or resource. BCWS is calculated as budget base line cost divided into phases and cumulative up to the status date, or current date. It is the budgeted cost.

BCWP (Budget cost of work performed) is the value that indicates the budget portion that should be spent, taking into account the work performed up to the moment and budget base line cost for the activity, allocation or resource. BCWP is also called Earned Value.

ACWP (Actual cost of work performed) value that shows actual costs incurred from the work already performed by a resource or task up to the status date or project current date from financial inputs.

Once these three parameters are determined, the outcome analysis is obtained based on the correlation between values found for each one in a given status date (Exhibit 5).

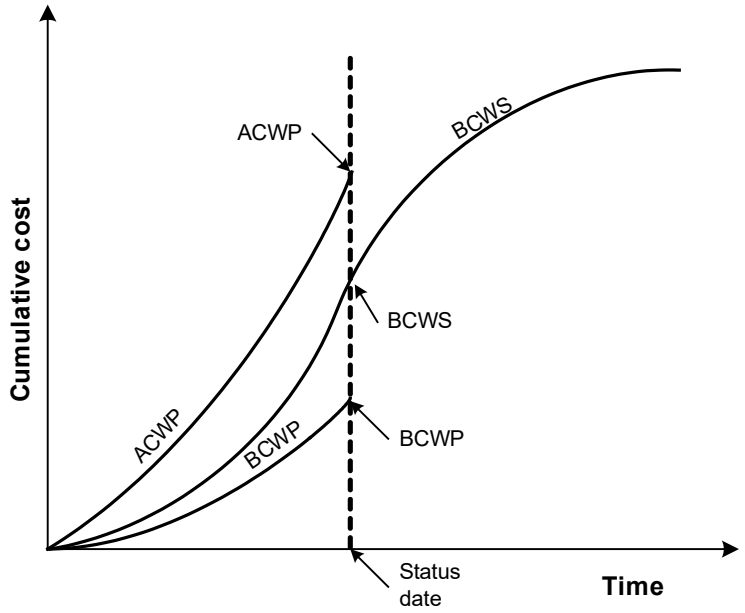

Exhibit 5 – BCWS, BCWP e ACWP graphic example throughout the time for a given project

The correlation among BCWS, BCWP and ACWP values allows to rate project outcomes and to proceed evaluations and future final cost forecasts.

To treat the ratio among BCWP and BCWS and ACWP parameters, there are the following indexes:

A) SPI (Schedule Performance Index) – Division between the Earned Value (BCWP) and the budgeted base line cost (BCWS). SPI shows the conversion rate of the budgeted value in the Earned value.

$$SPI = \frac{BCWP}{BCWS}$$

SPI equals 1 indicate that the budgeted value was completely earned to the project. SPI lower than 1 indicates that the project is being performed at a conversion rate lower than scheduled, that is, the financial amount scheduled to be earned in the period was not achieved and the project is late. SPI higher than 1 indicates that the project is earning outcomes in a speed higher than scheduled, i.e., it is advanced.

B) CPI (Cost Performance Index) – Division between the Earned Value (BCWP) and the actual cost and (ACWP). CPI shows the conversion between the actual values spent by the project and the earned values in the same period.

$$CPI = \frac{BCWP}{ACWP}$$

CPI equals 1 indicate that the value spent by the project was completely earned to the project (project in the budget). CPI lower than 1 indicates that the project is spending more than scheduled up to the moment. If CPI is higher than 1 indicates that the project is costing less than scheduled up to that moment.

Human Performance Index and Professional Evaluation Models

In order to allow the team evaluation ad project professional it was developed a new index called Human Performance Index (HPI). This index consists of the relationship between the CPI and SPI allowing the creation of an index that evaluates the accomplishment of the schedule and budget of the activities executed by the resource simultaneously.

In developing this paper, it was studied several types of relationship between indexes (sum, average, product, etc.), however, as the nature of the two indexes differs from the complete percentage of the project, it was chosen the composition of the indexes with complete percentage, where the participation of schedule performance index in the beginning of the project is higher than the cost performance index, while at the end of project occurs an inversion in the participation of indexes, once the SPI tends to 1 (BCWP→ BCWS) with the termination of the project.

The resulting formula is

$$HPI = \%_C \times CPI + (1 - \%_C) \times SPI$$

Where CPI = Cost performance index

SPI = Schedule performance index

$\%_C$ = Project complete physical percentage

Exhibit 6 observes it the participation of the indexes in the HPI composition along the project.

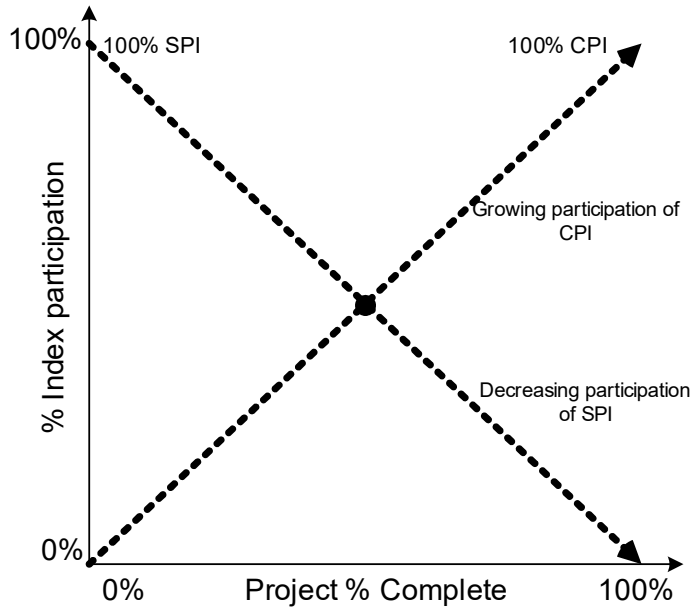

Exhibit 6 – Participation of the indexes according to project complete percentage

From the creation of this index, it is required to evaluate the HPI´s not only the individual work outcome but also the team work in which the resource is integral part of the project as a whole, creating a final HPI that is the weighed average of these three indexes as it is presented below:

$$HPI_{Individual} = \%_C \times CPI_{Individual} + (1 - \%_C) \times SPI_{Individual}$$

$$HPI_{Team} = \%_C \times CPI_{Team} + (1 - \%_C) \times SPI_{Team}$$

$$HPI_{Project} = \%_C \times CPI_{Project} + (1 - \%_C) \times SPI_{Project}$$

$$HPI_{Final} = \frac{HPI_{Individual} \times Peso_{Individual} + HPI_{Team} \times Peso_{Team} + HPI_{Project} \times Peso_{Project}}{Weight_{Individual} + Weight_{Team} + Weight_{Project}}$$

Where $CPI_{Individual}$ = Cost performance index of the work packages where the evaluated resource was involved

$SPI_{Individual}$ = Scheduled performance index of the work packages where the evaluated resource was involved

CPI_{Team} = Cost performance index of the team work packages of which the evaluated resource is participant

SPI_{Team} = Schedule performance index of the team work packages of which the evaluated resource is participant

$CPI_{Project}$ = Cost performance index of the project

$SPI_{Project}$ = Schedule performance index of the project

$Weight_{Individual}$ = Contribution of resource HPI in the HPIFinal

$Weight_{Team}$ = Contribution of team HPI in the HPIFinal

$Weight_{Project}$ = Contribution of project HPI in the HPIFinal

$\%_C$ = Project complete physical percentage

HPI_{Final} can be obtained from different strategies starting from a strong focus on individual outcomes up to a balanced focus among the individual, team and project. Follows a model of weight composition for different focuses

	$Weight_{Individual}$	$Weight_{Team}$	$Weight_{Project}$
Individual Focus	60	20	20
Team Focus	20	60	20
Project Focus	20	20	60
Balanced Focus	40	30	30

Exhibit 7 – Example of a proposal of weight distribution for the HPI resource composition

It is important to emphasize that the resource, team and project HPI´s are not obtained from CPI and SPI´s work packages, but from the sum of the BCWS, BCWP and ACWP's resource activities and later from the formula application, CPI=BCWP/ACWP and SPI = BCWP/BCWS.

Example

In order to illustrate the index development it has a project composed of twenty different work packages to be performed by five resources in two teams. The resources 1, 2 and 3 belong to Team A and the resources 4 and 5 to Team B, respectively. In Exhibit 8 there is the distribution of the resources in the work packages.

	Resource 1	Resource 2	Resource 3	Resource 4	Resource 5	Team A	Team B
Package 01	Resource 1		Resource 3		Resource 5	Team A	Team B
Package 02		Resource 2	Resource 3		Resource 5	Team A	Team B
Package 03				Resource 4			Team B
Package 04	Resource 1	Resource 2	Resource 3	Resource 4		Team A	Team B
Package 05			Resource 3		Resource 5	Team A	Team B
Package 06			Resource 3		Resource 5	Team A	Team B
Package 07	Resource 1		Resource 3			Team A	
Package 08	Resource 1	Resource 2	Resource 3			Team A	
Package 09		Resource 2		Resource 4		Team A	Team B
Package 10		Resource 2		Resource 4	Resource 5	Team A	Team B
Package 11		Resource 2	Resource 3		Resource 5	Team A	Team B
Package 12	Resource 1		Resource 3			Team A	
Package 13				Resource 4			Team B
Package 14	Resource 1		Resource 3	Resource 4		Team A	Team B
Package 15		Resource 2	Resource 3		Resource 5	Team A	Team B
Package 16				Resource 4	Resource 5		Team B
Package 17	Resource 1		Resource 3	Resource 4		Team A	Team B
Package 18				Resource 4			Team B
Package 19	Resource 1				Resource 5	Team A	Team B
Package 20		Resource 2	Resource 3		Resource 5	Team A	Team B

Exhibit 8 – Resource distribution to be used in the work packages

In a given moment of the project the package performance inputs were evaluated, obtaining the figure 9 with BCWS, BCWP and ACWP inputs for each work package

	%complete	Budget	BCWS	BCWP	ACWP
Package 01	25%	4.000,00	1.250,00	1.000,00	1.200,00
Package 02	50%	2.400,00	1.320,00	1.200,00	1.000,00
Package 03	100%	2.240,00	2.240,00	2.240,00	2.650,00
Package 04	75%	1.400,00	1.100,00	1.050,00	1.260,00
Package 05	25%	2.400,00	980,00	600,00	980,00
Package 06	50%	1.160,00	560,00	580,00	550,00
Package 07	75%	1.600,00	1.450,00	1.200,00	1.960,00
Package 08	25%	6.400,00	1.670,00	1.600,00	1.920,00
Package 09	100%	3.450,00	3.450,00	3.450,00	4.000,00
Package 10	75%	2.800,00	2.010,00	2.100,00	1.950,00
Package 11	25%	5.000,00	1.230,00	1.250,00	1.250,00
Package 12	50%	5.000,00	2.550,00	2.500,00	3.000,00
Package 13	25%	17.000,00	4.560,00	4.250,00	4.000,00
Package 14	50%	2.400,00	1.200,00	1.200,00	1.350,00
Package 15	100%	450,00	450,00	450,00	450,00
Package 16	75%	400,00	340,00	300,00	300,00
Package 17	25%	6.200,00	1.810,00	1.550,00	1.860,00
Package 18	100%	1.450,00	1.450,00	1.450,00	1.350,00
Package 19	50%	2.600,00	1.100,00	1.300,00	1.200,00
Package 20	25%	3.000,00	820,00	750,00	900,00
PROJECT	**42%**	**71.350,00**	**31.540,00**	**30.020,00**	**33.130,00**

Exhibit 9 – Example of data collected for a project with determined BCWS, BCWP and ACWP

From the overcome crossing of each package with resources used in them, it was obtained the HPI of each one of the resources, as well as the HPI of each one of the teams and the total HPI of the project according to Exhibit 10.

Resource	BCWS	BCWP	ACWP	CPI	SPI	% Complete	HPI
Resource 1	12.130,00	11.400,00	13.750,00	0,83	0,94	38,51%	0,90
Resource 2	12.050,00	11.850,00	12.730,00	0,93	0,98	47,59%	0,96
Resource 3	16.390,00	14.930,00	17.680,00	0,84	0,91	36,05%	0,89
Resource 4	18.160,00	17.590,00	18.720,00	0,94	0,97	47,11%	0,95
Resource 5	10.060,00	9.530,00	9.780,00	0,97	0,95	39,36%	0,96
Team	**BCWS**	**BCWP**	**ACWP**	**CPI**	**SPI**	**% Complete**	**HPI**
Team A	22.950,00	21.780,00	24.830,00	0,88	0,95	43,33%	0,92
Team B	25.870,00	24.720,00	26.250,00	0,94	0,96	42,37%	0,95
	BCWS	**BCWP**	**ACWP**	**CPI**	**SPI**	**% Complete**	**HPI**
Total	**31.540,00**	**30.020,00**	**33.130,00**	**0,91**	**0,95**	**42,07%**	**0,93**

Exhibit 10 – Project and resource HPI outcomes

Observing that each resource belongs to a given team, there are the following individual results, shown in exhibit 11.

Resource	$HPI_{Individual}$	HPI_{Team}	$HPI_{Project}$
Resource 1	0,90	0,92	0,93
Resource 2	0,96	0,92	0,93
Resource 3	0,89	0,92	0,93
Resource 4	0,95	0,95	0,93
Resource 5	0,96	0,95	0,93

Exhibit 11 – HPI results of each resource

From the combination of the results of exhibit 11 with the ones of exhibit 7, there are the final HPI of each resource from the individual, team and project focus and the balance focus among the three parameters, obtaining the exhibit 12.

HPI	Individual Focus	Team Focus	Project Focus	Balanced Focus
Resource 1	0,91	0,92	0,92	0,91
Resource 2	0,95	0,93	0,93	0,94
Resource 3	0,90	0,91	0,92	0,91
Resource 4	0,95	0,95	0,94	0,95
Resource 5	0,95	0,95	0,94	0,95

Exhibit 12 – HPI results of each resource

From these values it can be analyzed the outcomes of each one of the resources and its contribution for the project and team outcome, as per example, it is shown in the exhibit 13.

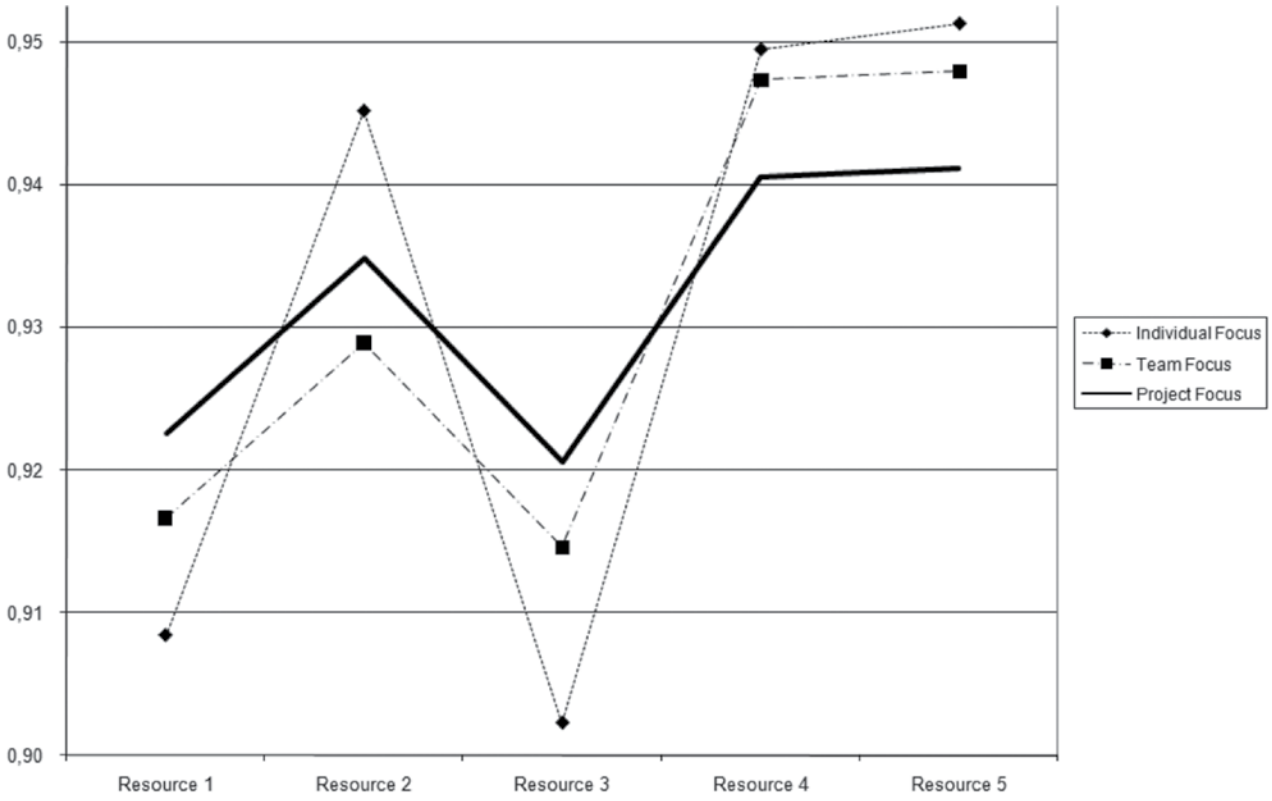

Exhibit 13 – Comparative graphic of the focuses among the individual, team and project for the 5 evaluated resources

In this example, it is observed that the resources 1 and 3 showed a performance lower than their team and project; the resource 2 showed a higher individual performance, however, in analyzing its team, its performance was damaged by weak performance of resources 1 and 3. Resources 4 and 5, they had high performance, increasing this way the performance of Team B. The project performance was lower than the 4 and 5 resources performance and Team B because the members of Team A lowered the global performance by their weak individual performances.

Conclusions

The main objective of this paper was to present an evaluation proposal of the human resources and teams through more direct mathematical model than the subjective evaluation by the project manager. Besides, bonuses and reward policies may be directly connected to the indexes causing more transparent mechanism of the distribution of project outcomes

However, some cautions have to be taken in using this kind of evaluation. First, when the executer is not the responsible for the budget accomplishment, he/she can have his/her performance compromised by weak performance of the procurement team, as an example. Secondly, this mathematical model may not be deterministic, i.e., the only one to represent the truth of the work outcome of the project resource, once they are completely mathematical, they may not evidence subjective human aspects inside the team work.

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RICARDO VARGAS

EARNED VALUE PROBABILISTIC FORECASTING USING MONTE CARLO SIMULATION

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Curitiba – PR – Brazil – 2004

Abstract

The aim of this article is to present a proposal of interconnection between models and probabilistic simulations of project as possible ways to determine EAC (Final cost) through Earned Value Analysis. The article proves that the use of the 3 main models of projection (constant index, CPI and SCI) as the basis of a triangular probabilistic distribution that, through Monte Carlo simulation will permit associate and determine the probability according to the accomplishment of budgets and costs of the project.

Related Podcasts

♫ Earned Value Project Management
http://rvarg.as/bk

♫ *Monte Carlo Simulation*
http://rvarg.as/bi

♫ *4 Mechanisms for Forecast the Project Schedule and Cost*
http://rvarg.as/15

♫ *4 Different Indexes to Forecast the Project Final Cost Using the Earned Value Analysis*
http://rvarg.as/21

♫ *Understanding the Difference Between Cost and Price*
http://rvarg.as/4x

♫ *The WBS Dictionary*
http://rvarg.as/51

Earned Value Analysis

Earned Value focuses on the relation between actual costs and the work done in the project within a certain time limit. The focus is on the performance obtained in comparison to what was spent to obtain it (FLEMING & KOPPELMAN, 1999a).

Earned Value can be defined as the evaluation between what was obtained according to what was truly spent and to what was planned to be spent, in which it is suggested that the value to be earned initially by an activity is the value budgeted for this activity. As each activity or task of a project is accomplished, that value initially budgeted for the activity, now builds the Earned Value of the project.

In order to formalize the concepts mentioned before, based on the norm ANSI/EIA 748 of the American National Standards Institute, a specific terminology was made up, based on data of the forecasted cost, real cost and earned value.

The 3 Elements of the Earned Value Analysis

A project that will be controlled through the Earned Value Analysis needs to be planned through the management basic principles, applicable to any kind of project.

Exhibit 1 evidences these management processes. Firstly, the work to be done is defined. In a second moment, the schedules and budgets are developed. The measurement and evaluation of the results of Earned Value are then, determined and compared to the planned values.

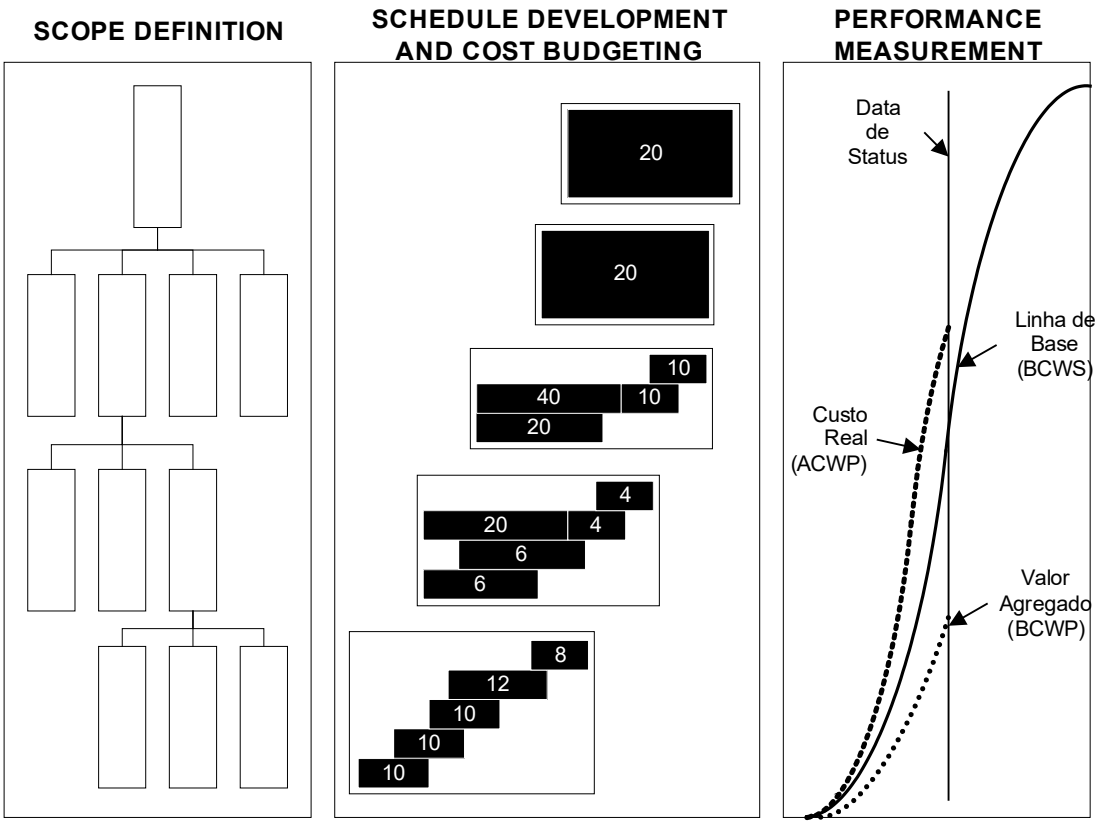


Exhibit 1 – Planning and monitoring system using Earned Value Analysis (ABBA, 1998).

Likewise, the PMI (2000) shows, in its process of planning (Exhibit 2), a detailing of processes of planning according to the same steps mentioned by ABBA (1998), in which the scope definition of the project (Scope Definition – 5.3) is prerequisite for schedule development (Schedule Development – 6.4), for resource allocation (Resource Planning – 7.1) and for cost budgeting (Cost Budgeting – 7.3). Based on the conclusion of these processes, the project plan is developed (Project Plan Development – 4.1).

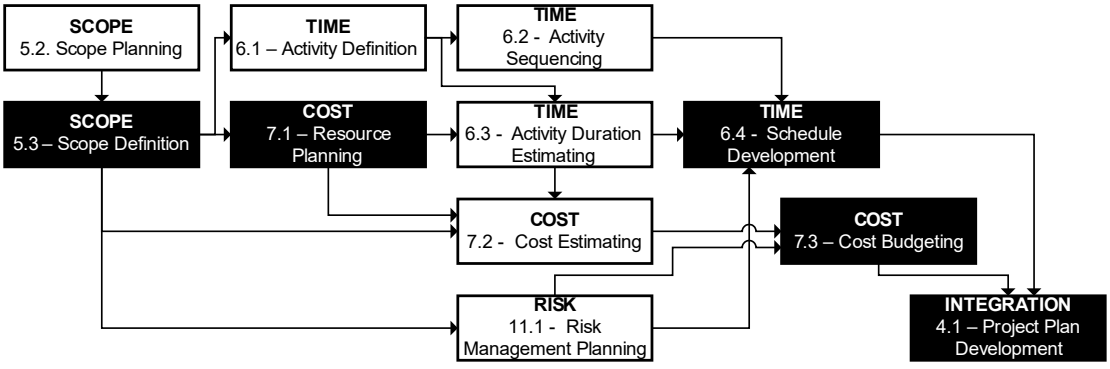


Exhibit 2 – Planning processes (PMI,2000).

BCWS (Budget cost of work scheduled) is the value that points out the part of the budget that should be spent, considering the cost of baseline of the activity,

attribution or resource. The BCWS is calculated as the costs of baseline divided in phases and accumulated until the date of the status, or current date. It is the cost originated in the budget.

During the execution, the monitoring of the progress of the project is made through the comparison between the real results obtained and the ones forecasted by the project in the BCWS. In this moment, the Earned Value of the work (BCWP) is evaluated, as well as the appropriation of real costs (ACWP).

BCWP (Budget cost work performed) is the value that points out the part of the budget that should be spent, considering the work done up to the moment and the cost of baseline for the activity, attribution or resource. The BCWP is also called Earned Value.

The way of measurement of Earned Value, or BCWP, is directly linked to the way the project was planned. Without an adequate planning, the measurement of performance has little or no applicability.

HARROFF (2000) and FLEMING & KOPPELMAN (1999) subdivide the measurement of Earned Value (BCWP) in different methods:

1. **Milestone with weighted value:** The control cell is converted in 2 or more marks where each one of them is defined by a partial delivery of the work, generating, consequently, a specific cost. The sum of the costs of accomplishment of each one of these marks is the cost of the item.
2. **Fixed formula by CAP:** It is the method that divides CAP in 2 parts that, if summed up, complete 100% of the work. In general, the most used formulas are 25/75, 50/50 and 75/25. The formula 25/75 separates the work in 2 points: the first point is accomplished immediately at the beginning of CAP (25% of costs are already accounted); the other 74% are accounted when the work is finished. The formula 50/50 points out that 50% of costs will be accounted at the beginning of the work and 50% at the end.
3. **Percent complete:** This method attributes to each element of a certain percent complete (between 0 and 100%) to each control cycle. This percentage is multiplied by the forecasted cost, aiming to determine the part of the budget already done.
4. **Equivalent units:** It is a method that calculates the Earned Value based on the units produced or made by individual elements of costs, applied in repetitive works or where the elements are defined in terms of direct consumption of resources.

It is common sense in all Earned Value reports that there is not only one method able to fulfill all kinds of work. Most of the times, companies should allow the use of more than a mechanism of Earned Value calculation.

In this article we decided to choose the use of percent complete as a way to determine Earned Value (BCWP), due to its popularity and user-friendliness. The

percent complete is being more used in projects because it is easy to use and it is a standard entry mechanism for earned values in many project management software.

On the other hand, it brings a huge obstacle in its use, which is the strong subjectivity in its evaluation. It is influenced directly by the evaluator's perception. Since the data entry relies on the individual perception, the percent complete method can be threatened by clients' pressure or by management staff, and as a consequence it could harm the results obtained. In order to minimize those problems, some companies have been using internal evaluation procedures of percent complete. The use of Earned Value in projects leads to more precise estimates.

The actual costs (ACWP) are measured and evaluated by the project team that is in charge of accounts payable and receivable or by the finance department of the same company. The team is supposed to report the real cost of the project until the dead line (status) in a specified accounts plan, defined by the controller's department of the enterprise.

ACWP (Actual cost of work performed) presents the actual costs resulting from the work already done by a resource or activity, until the status date, or actual date of the project, due to financial data. When those 3 parameters are defined, the analysis of results is obtained based on the correlation among the values found for each one of them in a certain status date.

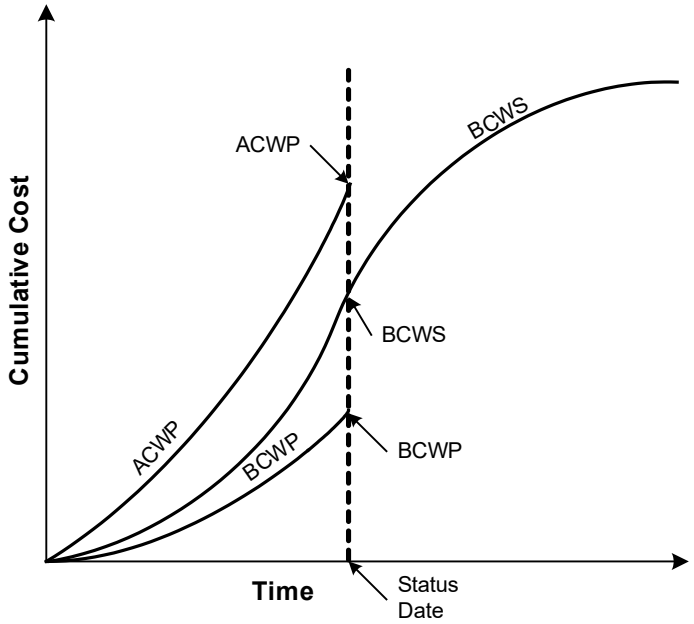


Exhibit 3 – Graphic example of BCWS, BCWP and ACWP within a time length.

Project Evaluation and Development of Projections with the Earned Value Analysis

The correlation among the values of BCWS, BCWP and ACWP allows the verification of the results of the project and continue the evaluations and future projections of final costs

In order to relate between BCWP and the parameters BCWS and ACWP there are the following indexes:

A) SPI (Schedule Performance Index) – Division between the Earned Value (BCWP) and the planned value in the baseline (BCWS). The SPI shows the conversion rate of the forecasted value in Earned Value.

$$SPI = \frac{BCWP}{BCWS} \qquad \text{(equation 01)}$$

When the SPI equals 1 it means that the planned value was integrally earned to the project. When the SPI is less than 1 it means that the project is being done in a lower conversion rate than the forecasted one. In other words, the forecasted financial amount to be earned in the period defined couldn't be obtained, and the project is late. When the SPI is superior to 1, it means that the project is earning results faster than expected, in other words, it is advanced.

B) CPI (Cost Performance Index) – Division between the Earned Value (BCWP) and the actual cost (ACWP). The CPI indicates which the conversion is between the actual values used by the project and the earned values in the same period.

$$CPI = \frac{BCWP}{ACWP} \qquad \text{(equation 02)}$$

When the CPI equals 1, it means that the value spent by the project was integrally earned to the project (project within the budget). When the CPI is less than 1, it means that the project is spending more than forecasted until that moment. If the CPI is superior to 1, it means that the project costs less than forecasted until that moment. When CPI equals 1, it means that the project is according to the forecasted budget until the reference date. According to project forecasting, the following terminology is used:

A) EAC (Estimated at Completion) – finance value that represents the final cost of the project when concluded. It includes the actual costs (ACWP) and the rest of estimate values (ETC)

$$EAC = ACWP + ETC \qquad \text{(equation 03)}$$

B) ETC (Estimated to Complete) – financial value necessary to complete the project. It is calculated according to mathematical models to be presented.

C) VAC (Variation at Completion) – difference between the budgeted cost (BAC) and the projected final cost (EAC).

$$VAC = BAC - EAC \qquad \text{(equation 04)}$$

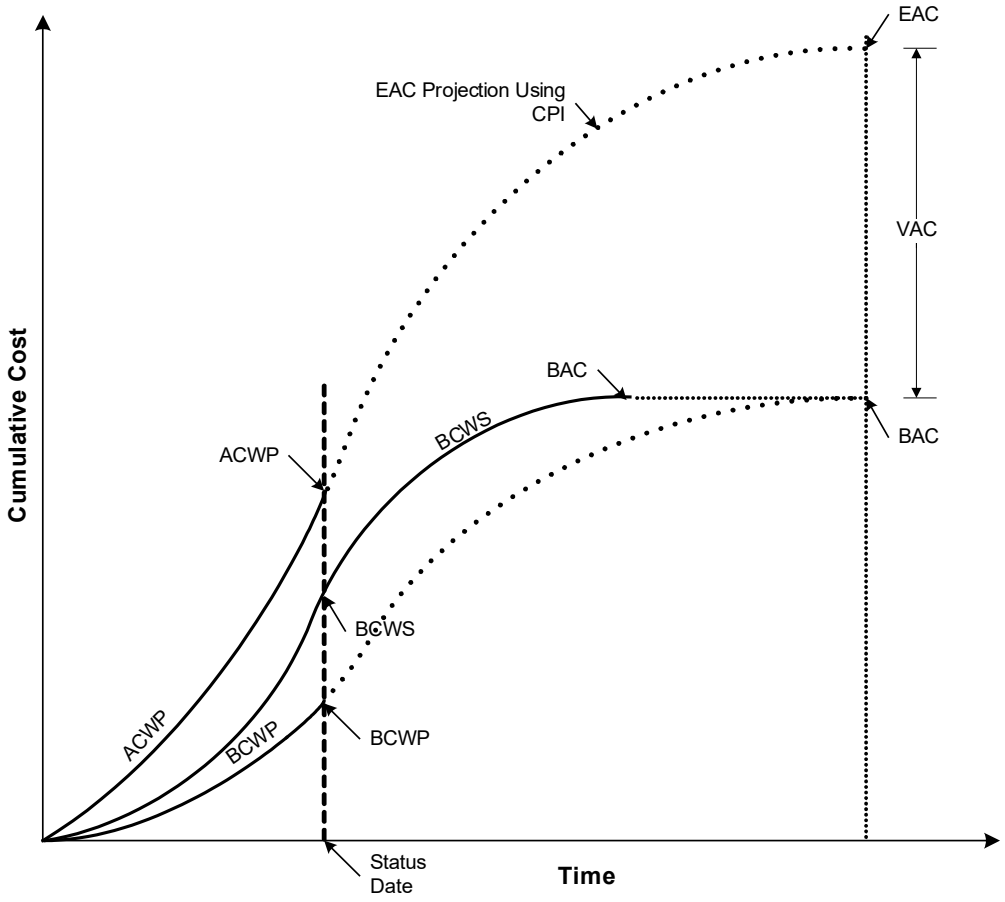


Exhibit 4 – Earned Value forecasting of final deadlines and final costs (GEROSA & CAPODIFERRO, 1999).

Indexes Used for Projection of Project Final Costs

The generic formula for the remaining estimated cost is function of a performance factor

$$ETC = \frac{BAC - BCWP}{Índice} \qquad \text{(equation 05)}$$

where BAC is the final budget of the final project and index is the performance index of the project.

The performance index is determined by the combination of the Cost Performance Index (CPI) with the Scheduled Performance Index (SPI), according to what is described next, in its usual cases.

ETC through the constant deviation index (optimistic)

It assumes that the rest of the work to be done by the project will be done according to the original plan and that an occurred deviation will not represent a tendency of degeneration or recovery of the forecasted budget.

This estimate is commonly called the Optimistic Estimation, because, the indexes CPI and SPI are usually less than 1, therefore permanence in the plan turns out to be a good result.

$$Índice = 1$$

$$ETC = \frac{BAC - BCWP}{Índice} = BAC - BCWP$$

$$EAC = ACWP + ETC = ACWP + BAC - BCWP \qquad \text{(equation 06)}$$

ETC through costs performance index (realistic or more probable)

It assumes that the rest of the work to be done by the project will follow the same finance performance obtained until this moment, through the costs performance index (CPI).

A negative or positive tendency obtained up to the moment in terms of CPI, will project the same tendency for the final costs of the project. Since, there is a natural tendency to work with CPI indexes inferior to 1, this estimate is commonly called Realistic Estimation or more probable.

$$Índice = CPI$$

$$ETC = \frac{BAC - BCWP}{Índice} = \frac{BAC - BCWP}{CPI}$$

$$EAC = ACWP + ETC = ACWP + \frac{BAC - BCWP}{CPI} \qquad \text{(equation 07)}$$

ETC through future scheduled cost index SCI (pessimistic)

It assumes that the rest of the work (future) to be done by the project will follow the finance projection determined by the cost performance index (CPI), as well as the scheduled projection determined by the scheduled performance index, generating the scheduled cost index SCI.

This procedure aims to catch a natural human tendency of recovering the time wasted, and this try means to spend more resources to do the same work planned before. The SCI index is strongly applicable in EAC projection in case of late proj-

ects, and with forecasted costs overspent. The product SPIxCPI makes up the strictest index in order to determine the EAC.

Since there is a natural tendency to work with CPI and SPI indexes inferior to 1, this estimate is usually called Pessimistic Estimation.

$$Índice = SCI = SPIxCPI$$

$$ETC = \frac{BAC - BCWP}{Índice} = \frac{BAC - BCWP}{SPIxCPI}$$

$$EAC = ACWP + ETC = ACWP + \frac{BAC - BCWP}{SPIxCPI} \quad \text{(equation 08)}$$

When the 3 ways of Estimated at completion is determined, a probabilistic model is applied in the data, in order to allow verification, in a desired reliability degree, which is the projected final cost for the project.

Monte Carlo Simulation

"Monte Carlo" was a nickname of a top-secret project related to the drawing and to the project of atomic weapons developed by the mathematician John von Neumann. He discovered that a simple model of random samples could solve certain mathematical problems, that couldn't be solved up to the moment.

The simulation refers, however, to a method in which the distribution of possible results is produced from successive recalculations of the data of the project, allowing the construction of multiple scenarios. In each one of the calculations, new random data is used to represent a repetitive and interactive process. The combination of all these results creates a probabilistic distribution of the results.

The feasibility of produced distribution relies on the fact that, for a high number of repetitions, the model produced reflects the characteristics of the original distribution, transforming the distribution in a plausible result for analysis. The simulation can be applied in schedules, costs and other project indexes.

Mathematically the result of the simulation becomes a reasonable approximation for the original data. In an infinite number of repetitions, we could define that

$$\text{Re}sults = \int_{-\infty}^{+\infty} xF(x)dx \quad \text{(equation 09)}$$

where X is the variable analyzed and F is its density of probabilities function.

Since the exact determination of the integration xF(x) is rather complex, the simulations permits an approximate form of results with less complexity.

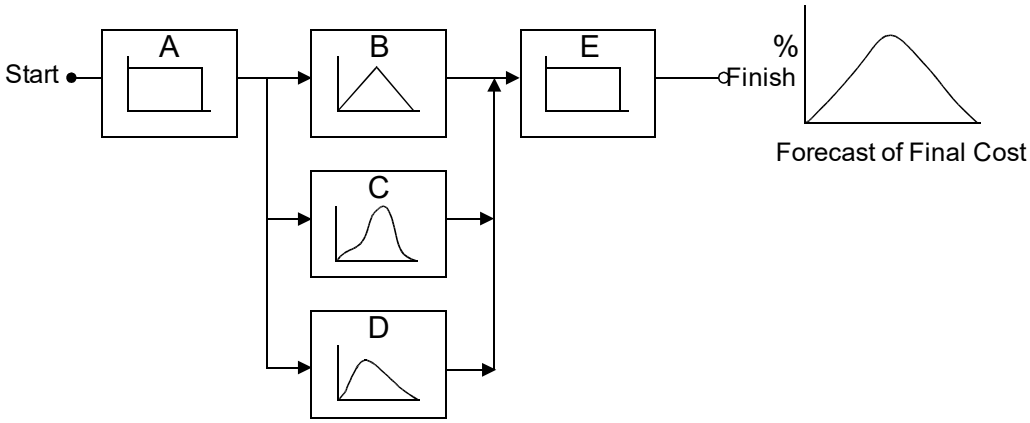


Exhibit 5 – Construction of model of distribution of costs and activities or work packages making up a final distribution from random data of the project (PRITCHARD, 2001).

Execution of the Simulation

The execution of the simulation assumes that all data of SPI, CPI and EAC's have already been determined for each activity or work package, according to what was evidenced in the project example shown as follows.

[1] In this paper all the case study data are displayed in Brazilian Portuguese, as the original article.

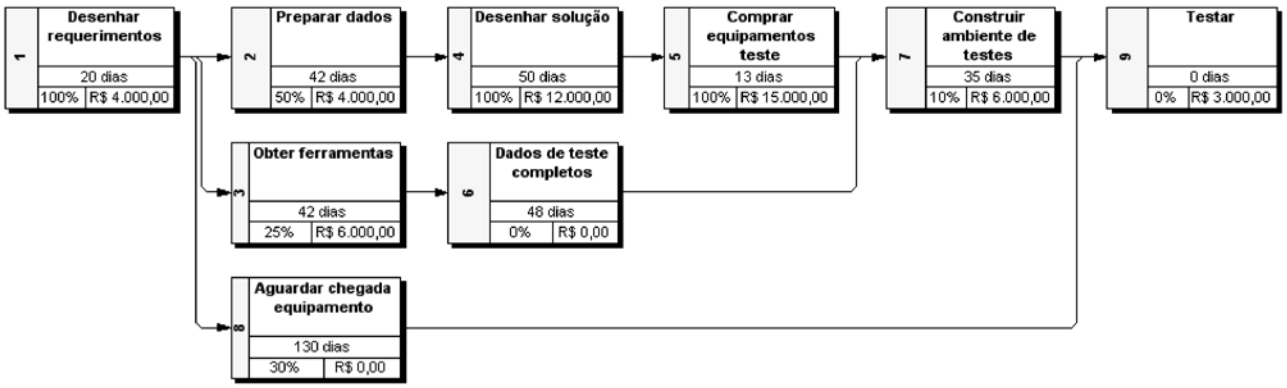


Exhibit 6 – Project example using the simulation.[1]

NAME	% COMPLETE	BUDGET	BCWS	BCWP	ACWP	CV
Simulação	**41%**	**R$ 50.000,00**	**R$ 41.200,00**	**R$ 35.100,00**	**R$ 37.400,00**	**(R$ 2.300,00)**
Desenhar requerimentos	100%	R$ 4.000,00	R$ 4.000,00	R$ 4.000,00	R$ 5.000,00	(R$ 1.000,00)
Preparar dados	50%	R$ 4.000,00	R$ 3.000,00	R$ 2.000,00	R$ 5.000,00	(R$ 3.000,00)
Obter ferramentas	25%	R$ 6.000,00	R$ 6.000,00	R$ 1.500,00	R$ 3.000,00	(R$ 1.500,00)
Desenhar solução	100%	R$ 12.000,00	R$ 12.000,00	R$ 12.000,00	R$ 10.000,00	R$ 2.000,00
Comprar equipamentos teste	100%	R$ 15.000,00	R$ 15.000,00	R$ 15.000,00	R$ 13.500,00	R$ 1.500,00
Dados de teste completos	0%	R$ 0,00	R$ 0,00	R$ 0,00	R$ 0,00	R$ 0,00
Construir ambiente de testes	10%	R$ 6.000,00	R$ 1.200,00	R$ 600,00	R$ 900,00	(R$ 300,00)
Aguardar chegada equipamento	30%	R$ 0,00	R$ 0,00	R$ 0,00	R$ 0,00	R$ 0,00
Testar	0%	R$ 3.000,00	R$ 0,00	R$ 0,00	R$ 0,00	R$ 0,00

NAME	SV	CPI	SPI	EAC CONSTANT	EAC CPI	EAC SCI
Simulação	**(R$ 6.100,00)**	**0,94**	**0,85**	**R$ 52.300,00**	**R$ 62.500,00**	**R$ 100.100,00**
Desenhar requerimentos	R$ 0,00	0,80	1,00	R$ 5.000,00	R$ 5.000,00	R$ 5.000,00
Preparar dados	(R$ 1.000,00)	0,40	0,67	R$ 7.000,00	R$ 10.000,00	R$ 12.500,00
Obter ferramentas	(R$ 4.500,00)	0,50	0,25	R$ 7.500,00	R$ 12.000,00	R$ 39.000,00
Desenhar solução	R$ 0,00	1,20	1,00	R$ 10.000,00	R$ 10.000,00	R$ 10.000,00
Comprar equipamentos teste	R$ 0,00	1,11	1,00	R$ 13.500,00	R$ 13.500,00	R$ 13.500,00
Dados de teste completos	R$ 0,00	-	-	R$ 0,00	R$ 0,00	R$ 0,00
Construir ambiente de testes	(R$ 600,00)	0,67	0,50	R$ 6.300,00	R$ 9.000,00	R$ 17.100,00
Aguardar chegada equipamento	R$ 0,00	-	-	R$ 0,00	R$ 0,00	R$ 0,00
Testar	R$ 0,00	-	-	R$ 3.000,00	R$ 3.000,00	R$ 3.000,00

Exhibit 7 – Initial basic data of simulation and determination of the 3 models of EAC (optimistic, pessimistic and realistic).

From a complete database, the function of distribution of probability is determined for the 3 EAC data, building the medium EAC as a result of distribution, as shown at table below.

The function of density of probability used in the simulation will be the triangular distribution. This distribution is determined based on its minimum value, its more probable value and its maximum value. This function is probably the most direct and simplest among distributions (GREY, 1995), requiring only 3 points in its built.

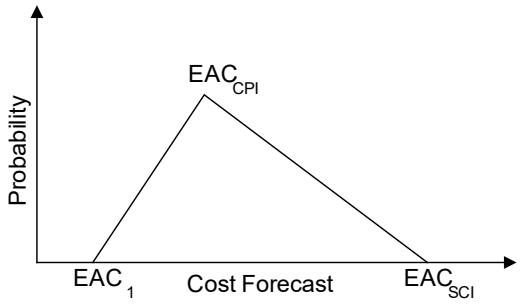


Exhibit 8 – Function of density of triangular probability for EAC.

Using the simulation software @Risk, we could determine the final EAC from the function RiskTriang (EAC1, EAC cpi, EAC sci), making up the results evidenced at table below.

NAME	EAC CONSTANT	EAC CPI	EAC SCI	EAC	EAC
Simulação	**R$ 52.300,00**	**R$ 62.500,00**	**R$ 100.100,00**	**=RiskOutput()**	**R$ 71.633.33**
Desenhar requerimentos	R$ 5.000,00	R$ 5.000,00	R$ 5.000,00	=RiskTriang(E16; F16; G16)	R$ 5.000,00
Preparar dados	R$ 7.000,00	R$ 10.000,00	R$ 12.500,00	=RiskTriang(E17; F17; G17)	R$ 9.833,33
Obter ferramentas	R$ 7.500,00	R$ 12.000,00	R$ 39.000,00	=RiskTriang(E18; F18; G18)	R$ 19.500,00
Desenhar solução	R$ 10.000,00	R$ 10.000,00	R$ 10.000,00	=RiskTriang(E19; F19; G19)	R$ 10.000,00
Comprar equipamentos teste	R$ 13.500,00	R$ 13.500,00	R$ 13.500,00	=RiskTriang(E20; F20; G20)	R$ 13.500,00
Dados de teste completos	R$ 0,00	R$ 0,00	R$ 0,00	=RiskTriang(E21; F21; G21)	R$ 0,00
Construir ambiente de testes	R$ 6.300,00	R$ 9.000,00	R$ 17.100,00	=RiskTriang(E22; F22; G22)	R$ 10.800,00
Aguardar chegada equipamento	R$ 0,00	R$ 0,00	R$ 0,00	=RiskTriang(E23; F23; G23)	R$ 0,00
Testar	R$ 3.000,00	R$ 3.000,00	R$ 3.000,00	=RiskTriang(E24; F24; G24)	R$ 3.000,00

Exhibit 9 – Function of density of triangular probability determined for the final EAC.

When we build the function of density of probability, the parameters of simulation are determined, as well as the number of iterations and repetitions of simulation and other information. In this article 50,000 iterations were made.

The number of iterations is important to determine the quality of the results, therefore, the more iterations are made, the more the function of final density gets closer to the original functions. However, this kind of process requires a long execution time, even for fast computers that are able to make the simulation in high speed.

SUMMARY INFORMATION	
Workbook Name	eva.xls
Number of Simulations	1
Number of Iterations	50.000
Number of Inputs	9
Number of Outputs	1

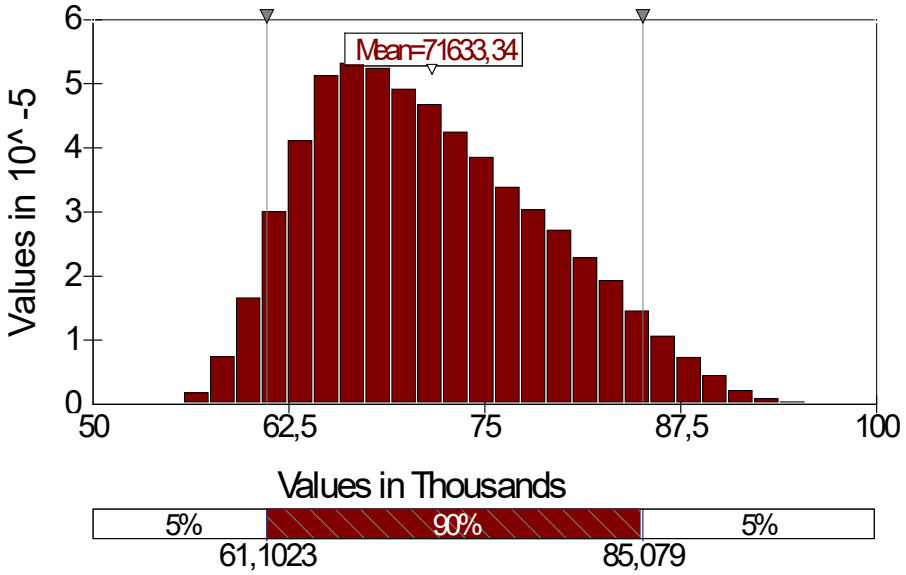
Exhibit 10 – Simulation data.

SUMMARY INFORMATION	
Sampling Type	Latin Hypercube
Simulation Start Time	20/1/2004 13:26
Simulation Stop Time	20/1/2004 13:27
Simulation Duration	00:00:55
Random Seed	1102974243

Exhibit 10 – Simulation data.

Analysis of the Results

After doing the simulation, the product generated is a distribution of probability of final EAC of the project, called "Simulation", evidenced in the following exhibits.



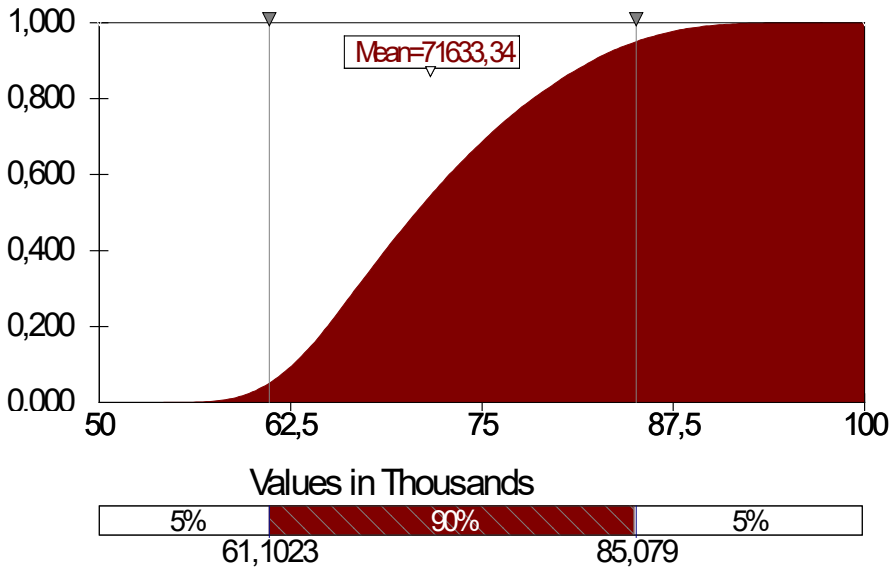


Exhibit 11 – Distribution for the final EAC of the Project "Simulation" with an interval of confidence of 90% and cumulative distribution for the final EAC of the Project "Simulation".

%TILE	VALUE	%TILE	VALUE
5%	R$61.102,32	55%	R$71.753,30
10%	R$62.673,17	60%	R$72.871,88
15%	R$63.868,52	65%	R$74.055,95
20%	R$64.892,36	70%	R$75.366,22
25%	R$65.850,78	75%	R$76.773,88
30%	R$66.776,27	80%	R$78.350,77
35%	R$67.728,09	85%	R$80.126,48
40%	R$68.686,84	90%	R$82.236,36
45%	R$69.675,42	95%	R$85.078,99
50%	R$70.702,85		

Exhibit 12 – Percentage distribution of final EAC of Project "Simulation".

According to prior data, we can assume for sure (about 90% of certainty), for example that the projected final cost will be between $61,102 and $85,078.

These intervals could be altered in order to determine more or less precision. For example, assuming a certainty of 99% regarding the values, we obtain the interval between $57,858 and $90,792, according to what is shown in the following exhibit.

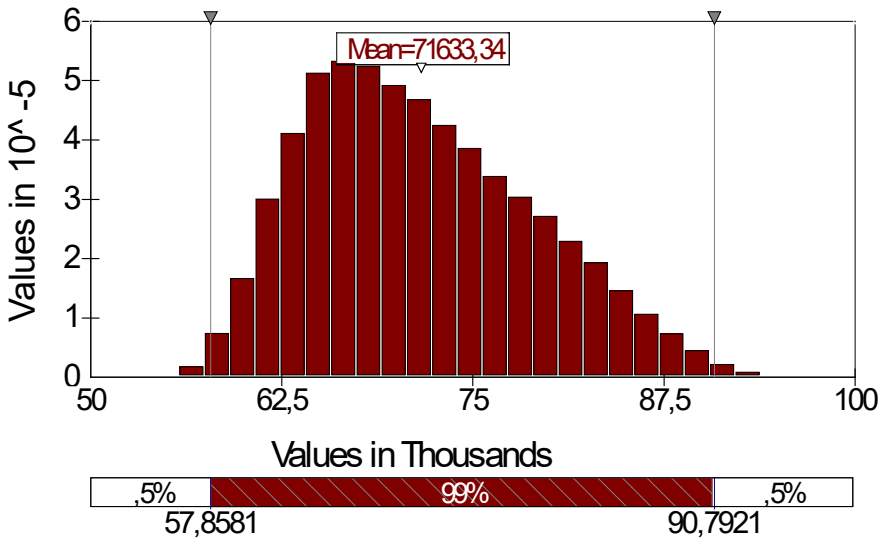


Exhibit 13 – Distribution for the final EAC of the Project "Simulation" with an interval of confidence of 99%.

Conclusions

The use of Simulation Monte Carlo with the data of final EAC of the project, can, in an associated way, contribute to a probabilistic vision and not a deterministic vision of the final costs elaborated for the project, without the additional effort in its construction.

As mentioned in the study of CHRISTENSEN (1993), there isn't an agreement in order to define which forecast model presents the best precision and applicability. However, many studies have been made in order to compare many models for the costs estimated in a certain project or group of projects, after its conclusion, aiming to identify which models are more precise and in which phases of the project they are applicable, as well as to associate a certain type of project to a certain index.

The need of estimates and costs projections is mentioned and characterized by DOD (1997) in Instruction 5000.2R in 1997 in 2 criterion.

Start with an estimate area for the final cost, reflecting the best and worst scenarios.(DOD, 1997).

Determine the estimate for the final cost that reflects the best professional judgment concerning costs. If the contract is at least 15% complete and the estimate is less than the calculated using the accumulated performance index, give an explanation (DOD, 1997).

However, none of these studies provides a probabilistic treatment for the projects, since the most adequate final EAC for the project is no longer an isolated

value and turns out to be a values area with certain probabilities, as suggested in this article.

As a suggestion for new works, the next step will be to evaluate the results produced in the simulation with the real results of concluded projects in order to determine the precision of data obtained, aiming to produce cases associated to the simulation model applied to EMVS.

Abbreviations

ACWP – Actual cost of work performed

BAC – Budget at completion

BCWP – Budget cost of work performed

BCWS – Budget cost of work scheduled

C/SCSC – Cost/Schedule Systems Control Criteria

CAPs – Cost Account Plans

CPI – Cost Performance Index

CV – Cost variation

DOD – United States of America Department of Defense

EAC – Estimated at completion

EMVS – Earned Value Management Systems

ETC – Estimated to complete

EVMS – Earned value Analysis

PMBOK® - A guide to the Project Management Body of Knowledge

PMI – Project Management Institute

SCI – Scheduled Cost Index (SPIxCPI)

SPI – Scheduled Performance Index

SV – Scheduled variation

VAC – Variation at completion

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RICARDO VARGAS

EARNED VALUE ANALYSIS IN THE CONTROL OF PROJECTS: SUCCESS OR FAILURE?

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Abstract

The objective of this paper is to present and discuss the main obstacles and benefits of the use of the Earned Value Analysis in projects, including factors to be improved and implemented during the project plan and actions to be taken while the project is accomplished and controlled. Also, through a real case study in civil construction field, the applicability of the technique is faced with a theoretical reference, in order to identify aspects of the applicability of the tool tested in case study. The results to be presented and discussed are subdivided in two parts:

The first one is about the different features of each business and its contribution for the success or failure in the implementation of the Earned Value Analysis, and the second is about the characteristics of similarity found in all businesses that together favor or not the use of the tool.

Earned Value Analysis as a Control Technique

Many studies about the applicability of the Earned Value Analysis have been made. THAMHAIN (1998) tried to evaluate the popularity of different practices of project management. Surveys were made with 400 professionals who work with projects (managers, directors, people in charge) in 180 projects in Fortune-1000 companies. They were asked about the popularity and value of different techniques of performance evaluation. As a result, he could see that the Earned Value Analysis is used by 41% of people who work with projects. It is more used than critical path method, QFD (quality function deployment) and Crashing, among others. The Earned Value Analysis is almost as popular as the net PERT/CPM.

Concerning the value of the technique, the results found for Earned Value Analysis are fitted in a layer of little value, staying below practically all techniques analyzed, what infers that the popularity of the technique doesn't seem to show its applicability or value.

Trying to justify the low value proved by researchers, THAMHAIN (1998) states that little applicability found as a result in the studies made, can be attributed to different barriers, either being internal or from the environment. They are

- lack of comprehension of how the technique works;
- anxiety concerning the adequate use of the tool;
- use of the tool requiring a lot of work and time consumption;
- tools trimming creativity in the use of other strategies;
- inconsistency of the tool in managerial procedures / businesses processes;
- method of control as threat, concerning the freedom of the team;
- vague and inaccurate purpose and its benefit;
- high cost of its implementation;
- unsuccessful prior experience in the use of other techniques;
- low familiarity with the technique.

WIDEMAN (1999) states that a project of great importance requires a unit of planning and control that has professionals capable of collecting the information and making the Analysis of Added Value, turning its applicability justifiable.

CHRISTENSEN (1998) states, in his studies about the applicability of Added Value in govern organizations in the United States, that the implementation of Earned Value requires a cultural change, which demands time and effort. This means to make sure that policies and knowledge are taught by the organization and by the project in order to quicken the work of the ones involved.

To Sparrow (2000), the Earned Value Analysis enables a supplementary value to the project because it offers a premature visibility of its results, in other words,

it is possible to determine a tendency of costs and deadlines of the project in a certain phase of it, when there is still a possibility of implementation of corrective actions.

On the contrary, WEST & MCELROY (2001) agree that the Earned Value Analysis is an adequate tool for the generation of reports of work done, and not a managerial tool, since the control in real time of the project, using all parameters of analysis becomes unviable: "the Earned Value Analysis shows to the project team the performance obtained until then, and not the future forecast of the project."

WIDEMAN (1999) supports that the technique is conceptually attractive, however it requires great efforts in its maintenance, therefore it needs a qualified team to understand and provide reliable information. He also states that many project managers don't consider the analysis an appropriate cost-benefit ratio.

From those opposite points of view, we may imply that the Earned Value Analysis is a group of powerful intrinsic characteristics, wide and varied, like payment projection and forecasting. However, it is bound to find great difficulty in either data collection or in the low speed of information generation.

These considerations may mean that, if the data collection is made in adequate speed and accuracy, and the information is correctly compiled accomplishing the deadlines, the analysis has its applicability widely enlarged. Otherwise, it will not add much to the process of project control.

TERREL et al (1998) states that, in order to make the Earned Value Analysis effectively implemented, it is necessary to have the information about the resources clearly defined. A failure in obtaining these data, motivate the creation of inaccurate performance measurement baseline (PMB), distant from the real scenario.

FLEMING & KOPPELMAN (1999) state, also that another difficulty factor is about an adequate work breakdown structure (WBS). If the work is subdivided in small packages of work, it will represent a high cost of control and a lot of paperwork. On the other hand, a badly stratified subdivision may represent an inaccuracy of data, concerning real costs and deadlines.

This confirmation may be proved in the low application of the Earned Value Analysis in technology and marketing areas, where the creative work is the variant in a scope previously defined, making its application limited and directly related to the stability of a defined scope, according to PETERSON & OLIVER (2001).

They state that, the more short-term projects grow, with reduced team and a generically defined scope, the more the Earned Value Analysis, according to Instruction 5000. 2R (DOD, 1997) and by ANSI/EIA 748, is not viable, due to inaccurate

projections, consequence of a badly defined scope and to high costs noticed by the entrepreneurs.

Case Study

The company researched belongs to a sector of civil construction, which applies project management in a steady way. It is a segment that most invests in researches and new tools in this field. Furthermore, it is the only one on the market that admits publicly the use of Earned Value Analysis in its process of construction control.

This company is the 11th in the national segment of heavy construction. It is also part of the three biggest groups in the segment in the country and a leader in other segments of the economy, such as government work and telecommunications. It has been on the market for more than 50 years. Its turnover in 2001 was about US$200,000,000 with 80 engineers and about 4000 workers in its personnel.

Concerning the case study, everything started through a process of interview in which three professionals from the southeast business planning unit of the company, gave their opinion about the process in a wide and clear way. These professionals were the first ones to be interviewed, because they have developed the construction control system using the Earned Value Analysis.

After analyzing the issues discussed by the first interviewees, a new series of interviews was made, based on a new open line of interviews, with construction managers and the ones in charge of planning departments of each construction site. At this moment, the objective was to test the planning practices, analysis and gathering of data in different levels, aiming to find possible distortions, conceptual flaws, resistance and work style in the use of Earned Value Analysis in the construction sites.

In a third and final moment, the final result of the projects (deadlines and costs) was faced with the values computed for the Earned Value Analysis that were under the responsibility of the planning unit of the company. From that combination between interview results and the data available in the company, we tried to get evidence that could link the success or failure of the business to maturity in the use of Earned Value.

Concerning the evaluated construction sites, they were categorized by the company as medium-sized and average technique complexity constructions, which will be finished by the end of this work.

Results

The results to be presented and discussed in this section are about different characteristics of each construction site and its contribution to the success or failure in the implementation of the Earned Value Analysis. The second part is about the traces of similarity found in the construction sites and the general conclusions about the case study.

The results obtained in the process of interview and the combination of real data provided by the planning department, as seen before, were significantly different in each business.

From these different characteristics (Table 1), the main factors are presented and evaluated in each construction site, just like the final result concerning the fidelity of the results and the preliminary conclusions.

The factors evaluated have been presented in the discussion and analysis of each construction site, and they are: scope, deadlines and schedules, budget process, type of contract, type of client, partners and/or consortiums, organizational support, support by the client, geographic distribution of work, the presence of outsourced staff, use and knowledge of the indexes and models of projection provided by the tool.

As we can see, after analyzing table 1, we may conclude that the implementation of construction site one was successful and of construction site three was a failure. Both results are not necessarily product of an isolated factor, but from lots of linked factors.

CHARACTERISTIC	CONSTRUCTION SITE ONE	CONSTRUCTION SITE TWO	CONSTRUCTION SITE THREE
Scope	Clearly detailed and specified	Defined preliminary, detailed as the project is done	Detailed and specified satisfactorily (not in the same level of construction site one)
Deadlines and schedules set up	Closed and previously defined according to clear schedules to be followed	Open with schedules to be defined while duties are accomplished	Closed, but with significant changes throughout the project, result of problems linked to lack of financial funds.
Budget process	Structured through CAP's allowing the adequate use of the tool	Traditional, not based on the Analysis of Added Value	Traditional, not based on the Analysis of Added Value
Type of contract	Fixed price. Not adjustable	One price	One price
Type of client	Private	Public	Public

Table 1 – Comparative analysis of the main characteristics of three construction sites evaluated.

CHARACTERISTIC	CONSTRUCTION SITE ONE	CONSTRUCTION SITE TWO	CONSTRUCTION SITE THREE
Partnerships and/or consortiums	Nonexistent	Nonexistent	Consortium with another contractor that has the construction being controlled by the company evaluated
Organizational Support	High	Moderate to low	Moderate
Support by the client	High	Moderate	Moderate to low
Geographic distribution of work	Concentrated geographically	Concentrated geographically	Distributed in 150Km of groups of work
Presence of outsourced staff	None	None	High
Use of knowledge of indexes and models of projections provided by the tool	Moderate to low	Low	Low
Loyalty to official results presented with real results	High	Moderate to low	Low
Preliminary conclusion about the success of the implementation	Partial success	Partial failure	Failure

Table 1 – Comparative analysis of the main characteristics of three construction sites evaluated.

It is not possible to conclude that the unsatisfactory results found in construction site three are linked to the existence of a consortium or to an inadequate geographic distribution of work. This failure is a consequence of a group of many unfavorable characteristics, which contributed to unexpected results.

On the other hand, evaluating construction sites one and two, we find characteristics in construction site two that are significantly closer to those in construction site one. However, the main difference found was the lack of detailing of scope, which consequently made the budget process unsatisfactory. We may conclude that it was one of the main factors that made the results different (see Table 1).

Similarities have been found in all three projects evaluated. They are related to the process of interview and obtained results.

Initially, we may conclude that there are factors linked to the organizational structure and to the management model of the company that could affect directly the fidelity of results. Therefore, it is necessary to investigate deeply about the influence in organizational structure in the use of the tool.

Also, concerning organizational aspects, the ones in charge of construction sites planning, questioned the need of a high number of indexes, and mentioned that the determination of performance indexes was redundant.

A preliminary evaluation of these considerations, allows us to conclude, at first, that the Earned Value Analysis as we can see in all of the three projects, may show a high use of excessive indexes, superior of the management potential of a construction site. That could make the construction site impossible, result of low priority in the process and unnecessary use of indexes.

The opinion of the interviewees about the real value of the tool was unanimous. They all agree that the Earned Value Analysis is a great step for the improvement and introduction to a more modern mechanism of construction site control. This would confirm the first result of THAMHAIN'S (1998) study about how popular the technique is, however, in the same study (THAMHAIN, 1998), they all agree that the conditions of market and the necessity of a quicker generation of results, made the dedication to the use of the tool, difficult, proving the low value of the technique presented in the study of THAMHAIN (1998).

According to prior quotations, we can also see that in all three cases, there was an active participation of the planning departments of the business unit. However, this participation was different in each construction site. We can imply that the success of construction site 1, concerning the implantation of the tool, is directly linked to a strong presence of the professionals of planning department.

Therefore, we may conclude that, very often, the efforts of the construction site team are divided in many different groups, and the team dedicates to the tool, directly used by top executives to evaluate the businesses. As a result, the dedication to other competitive tools is ignored or left behind, as seen in Earned Value Analysis in projects two and three.

In construction site one, this process inverted. In this project, the Earned Value Analysis was the main mechanism of construction site control. It gathered all the necessary support to be successful. Finally, we may conclude that the case study proved the characteristics of the projects that favor the use of the tool and the use of others which show to be difficult in the process.

It was also proved that the implementation of the Earned Value Analysis is a complex process that involves several aspects, since the kind of business until its organizational structure, its scope, its geographic distribution and the relationship with the client, among others, that deserve a more detailed study.

Conclusions

From this paper, we may conclude that the Earned Value Analysis is a powerful tool in the control of performance evaluation. However, most of the projects have insufficiently detailed scope, staff with little experience in the use of the tool

and a natural dissociation in the control of costs and deadlines. These elements make the results questionable to a necessary effort.

We may also conclude that the results are not very obvious in short-term basis. They will only be evidenced in future phases of the project, especially in cost reduction of operations and rework.

As a third conclusion, we may see that, in projects of clearly defined scope, or in contracts with price and work established, the Earned Value Analysis shows a favorable cost-benefit ratio. Other element that might favor the application of the tool is the qualification of project teams in the use of the tool and the organizational support, which allows the tool to be simplified to meet the specific needs of the project and the organization.

To sum up, the combinations of the conclusions obtained from the analysis of the theoretical reference, with the case study are shown as follows.

Nature of the project – the application of the Earned Value Analysis can be considered more successful in projects of clear and tangible objectives, with a detailed scope, simple and direct. This type of project presents better results in the use of the analysis, as evidenced in the case study (construction site one). Projects with incomplete final products or services, or projects that involve aspects of creativity that make a precise plan impossible, show high inviability in the use of the technique. Since the planning has not been established, the date of performance can be determined (construction sites two and three).

Scope definition – from empirical evidence obtained from the evaluated construction sites and based on theoretical discussions presented in the theoretical reference, we may imply that the facility or difficulty concerning detailing and specification of scope, permits the tool to be favored or disfavored, since a tangible scope, controllable and detailed provides better specification of the work to be made. Consequently, it facilitates the process of measurement of real and added values. The establishment of tangible, controllable and detailed scope is a process that comes from the nature of the project and from the model of business established (contract, type of client, etc). Therefore, a strong dedication to the process of development of the scope improves results in the use in the Earned Value Analysis.

Informality in management and resistance to changes – we can see in the case study that the informality in the control of project is high, and resistance found in the implementation of a new model of control exists and cannot be ignored. This resistance is associated to a perception that the planning work and control rise in an unjustifiable way, when using the tool. Trying to associate both factors, ANT-

VIK (1998) states that the resistance comes from a cultural process of informality in the control of projects. In this way, it is implied that it is necessary to create a different work of management of changes, for example the training of management of projects, workshops, an efficient support of the professionals of this area, with prizes and bonuses. Everything aims to minimize the resistance found in the implementation and to favor the project environment.

Attractively and value of the technique – Based on the evidence of the case study and on researches presented on theoretical reference, we can say that the Earned Value Analysis is considered by the ones who have already used it or known it, as attractive and complete. However, this fact is not true, concerning the use of the technique. The interviewees and several authors that were cited and in this theoretical reference agree that the technique demands a strong effort that, if not analyzed widely, should not have good results. This consideration justifies the results presented on the research of THAMHAIN (1998).

Training – The Earned Value Analysis suggests a cultural change in the process of projects control, therefore people who have experience in dealing with the tool are really necessary in this process. Moreover, it is also necessary a process of intense training, in order to reduce the resistance to its implementation that comes originally from a low technical knowledge of the tool.

Organizational support – The way an organization implements the tool, influences directly the results. As seen empirically in the case study, the construction site one, that had an organizational support, provided by specialized resources, had better results in terms of application. However, the organizational support, has a cost that has to be determined and accounted, otherwise the obtained results might be distorted.

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RICARDO VARGAS

URGENCY: A CRITICAL FACTOR IN PROJECT PLANNING

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PMI Global Congress 2011 - North America

Dallas – Texas – USA – 2011

Abstract

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♫ Understanding the Effort Driven Task in a Project
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♫ Using Generic Resources in the Resource Allocation
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Given the natural speed and dynamism of the world, agility and sense of urgency has become preponderant in all projects. Challenging deadlines and budget make the management of these projects a risky activity. The more time and cost become challenging, the need for a more meticulous and detailed planning becomes fundamental. On the other hand, the urgency in the planning of these activities often directly affects the quality of the developed plans.

This article aims to discuss the costs and benefits of speed in developing a project plan and proposes a basic process that consists of 10 steps to plan and 10 steps to track a project in a short time. The process aims to simplify and prioritize critical documents to be developed in order to ensure the purpose, scope, deadlines and budgets, as well as direct restrictions of the project to be developed.

Finally, the article presents a list of success factors to be observed to handle and quickly develop effective project plans.

Urgency: the Costs and Benefits of Speed

A project is carried out to produce a beneficial change in the environment and it has three features (TURNER & MÜLLER, 2003):

- **It is unique:** there are not equal previous projects.
- **It is new:** previous projects did not use the same approach.
- **It is temporary:** it has a beginning and an end.

These features produce certain pressures, like the sense of urgency, the uncertainty and the need of integration. The urgency is directly related to the production of results within the shortest time.

OBJECTIVE	FEATURES	PRESSURES
To deliver Beneficial Change	**Unique**	**Uncertainty**
	Novel	**Integration**
	Temporary	**Urgency**

Exhibit 01 – Projects' features (TURNER & MÜLLER, 2003)

According to Betty Sue Flowers (MARCUS, 1998), people must have a sense of urgency even when they are facing a good situation. The sense of urgency doesn't come only from an emerging crisis, but also from the need to be ready for any situation, including opportunities.

Given this scenario, it is essential that the project manager respond immediately to requests from customers and from other interested with a legitimate sense of urgency (KERNION, 1999). Thus, the challenge becomes balancing the sense of urgency and pressure with time for reflection, experimentation and innovation that a unique product or service will require to be developed (EPPLER & SUKOWSKI, 2000).

Simplified Flow for the Development of Project Plan

In order to directly attend the need, we need to simplify the management process. Simplification occurs through careful analysis of the processes that may be deemed fundamental and essential. Importantly, only the processes considered crucial must be carried on, since we consider the speed of development as a priority, but it does not mean that other processes that are not listed cannot bring results in project planning.

The proposed flow is based on the PMBOK ® Guide (PMI, 2008), highlighting the sequence of activities that make up the process, starting from a assumption that there is already an assigned project manager. From the detailed processes in the guide, we set up a flow with 10 processes, as highlighted in Exhibit 01 and detailed below.

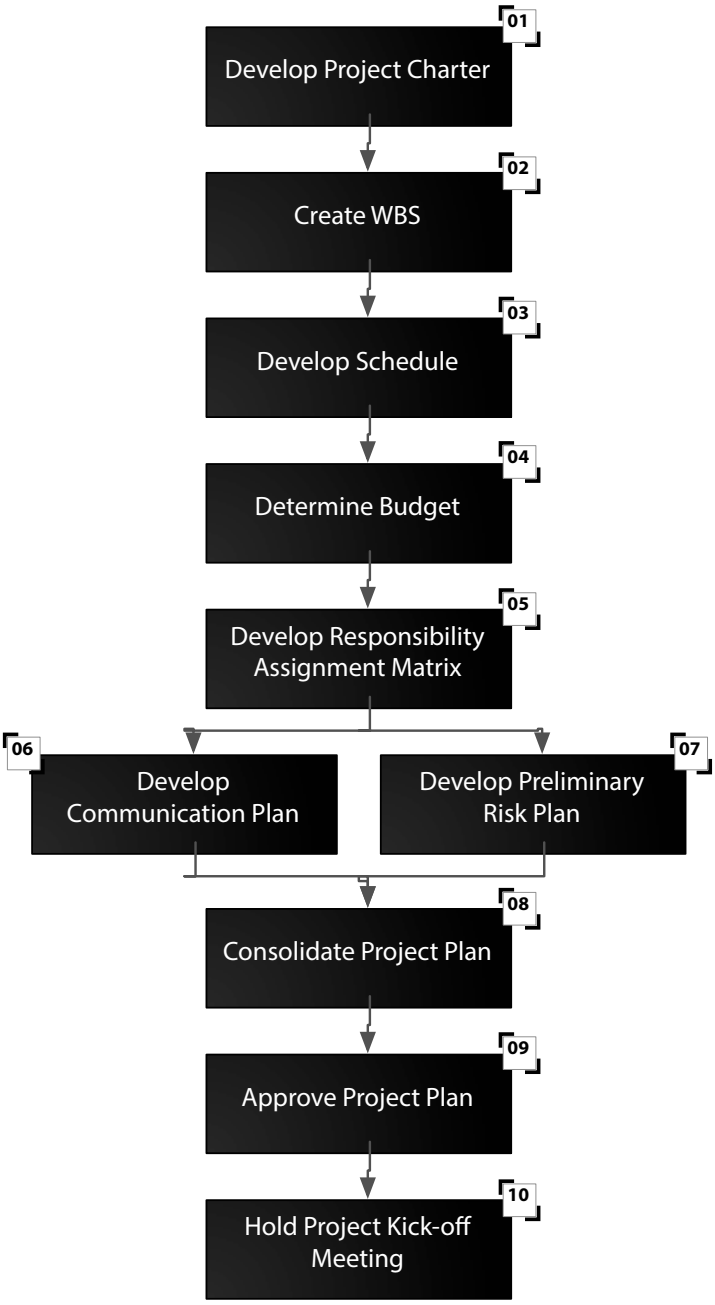

Exhibit 02 – Simplified flow for the development of Project Plan

1. Develop Project Charter – This process aims to develop the Project Charter that documents the business needs that will be attended by the projects, in addition to obtaining the commitment of areas / people involved and disseminate the official birth of the project to all interested. The Project Charter should be kept unchanged throughout the project. Its update is done in case of extreme change in the project, for example, changing the sponsor or the project manager, or a substantial change in the budget or schedule. The "urgent" Project Charter should also incorporate some elements that traditionally should be in the Scope

Statement. In this case, what is proposed is the development of a single document that brings together the main points of the Statement of Scope to the Project Charter.

2. Create the Work Breakdown Structure – Process that aims to develop the main tool of design of the project scope. The project WBS is a hierarchical structure that presents a visual decomposition of the project into smaller, more manageable parts, called "work packages". It must be constructed as "top-down" and detailed initially up into approximately 3 levels. The other levels will be updated and detailed with the development of projects through rolling waves planning models (GITHENS, 1998).

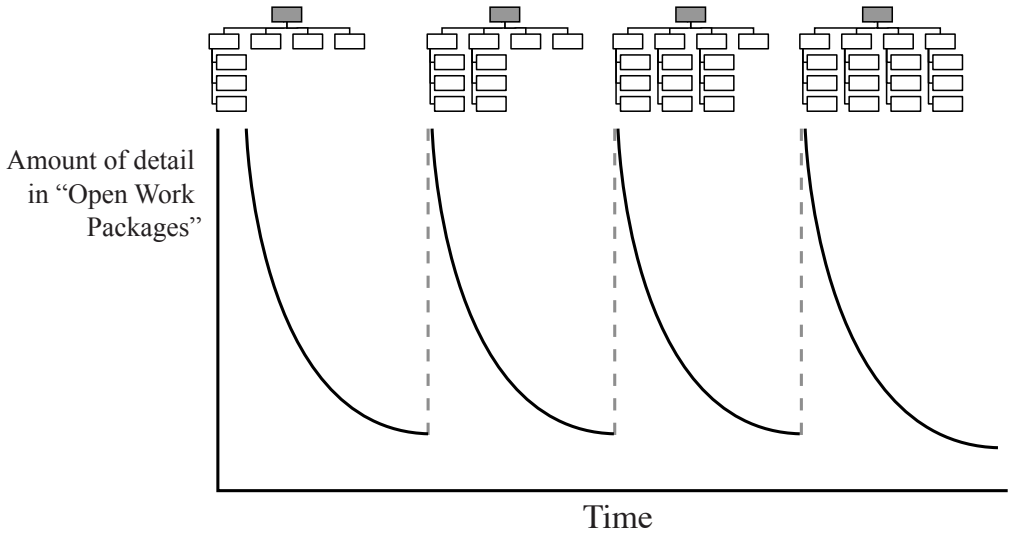

Exhibit 03 – Rolling Wave planning (GITHENS, 1998)

3. Develop Schedule – Process that assigns durations to work packages (lower level of WBS) and the precedence relationship between these packages, resulting in the project Network Diagram and Gantt chart. At this stage, the estimated duration of the project is determined.

4. Determine Budget – The objective of this process is developing the estimated cost of the project works that will consolidate the project budget and the baseline costs. The project budget should be developed at the level of detail that is compatible with the actual details of the work and can / should be refined with project updates.

5. Develop Responsibility Assignment Matrix – Process that aims to develop the spreadsheet that defines the responsibilities within the project. It lists the supplies and / or large blocks of WBS with the human resources responsible for implementation and approval of work, as well as the stakeholders to be informed and consulted. It is also known as RACI matrix (ARMSHAW, 2005).

6. Develop Communication Plan – Process that aims to develop a simplified spreadsheet highlighting who will receive the information (identified stakeholders), what is going to be informed, when communication is made, where the information will be collected, the reason why the communication is being performed, who is responsible for communication and how it is done and the cost of production of the information (5W and 2H).

7. Develop Preliminary Risk Plan – The objective of this process is to identify potential project risks using a structured approach to collect and document the identified risks, such as the Nominal Group Technique (NGT), Delphi and Brainstorming (ADAMS & MEANS, 2006). It is suggested that only threats are identified, ruling out opportunities for the process to be developed faster. Then, the identified risks are analyzed in terms of probability, impact and urgency, allowing that action plans can be developed in response to major risks. The risk plan will be updated throughout the work.

8. Consolidate Project Plan – Process that groups the documents previously produced in the Project Plan. Any presentations and supporting documents can also be consolidated into the plan to facilitate the process of presenting the project for approval.

9. Approve Project Plan – The objective of this process is to ensure that the responsible for the approval can review the documents and the analysis developed in the project plan, ensuring that all deliveries are planned in accordance with the stated objectives. The approval authorizes the commencement of work and turns the project plan approved at the baseline assessment of performance.

10. Hold Project Kick-off Meeting – The Project kick-off meeting is an extremely important event because it aims to promote the start of project activities and how it should contribute to achieving the Organization's strategic objectives. In addition to constitute itself as an opportunity that seeks to ensure the Organization's commitment to the project, it is considered the first work meeting of the core project team, in which the plan is presented, always seeking the involvement of the stakeholders.

Simplified Flow for Project Monitoring and Control

The update of the project plan developed according to the previous process can also be presented by 10 (ten) simplified procedures, including the approval process and implementation of changes. The simplified procedure for updating the plan is carried out repeatedly for each monitoring cycle.

The cycle time is determined by a function of the duration of the project and organizational planning parameters (ROSENHEAD, 2008). Usually, a project must have its monitoring cycle every 10% of the projected length; the minimum interval between cycles is 1 day and the maximum interval between cycles is 30 days. As an example, a project of 10 weeks suggests a break between cycles of 1 week as a project of 20 weeks suggests a break between cycles of 2 weeks.

The simplified flow for project monitoring and control is shown in Exhibit 04.

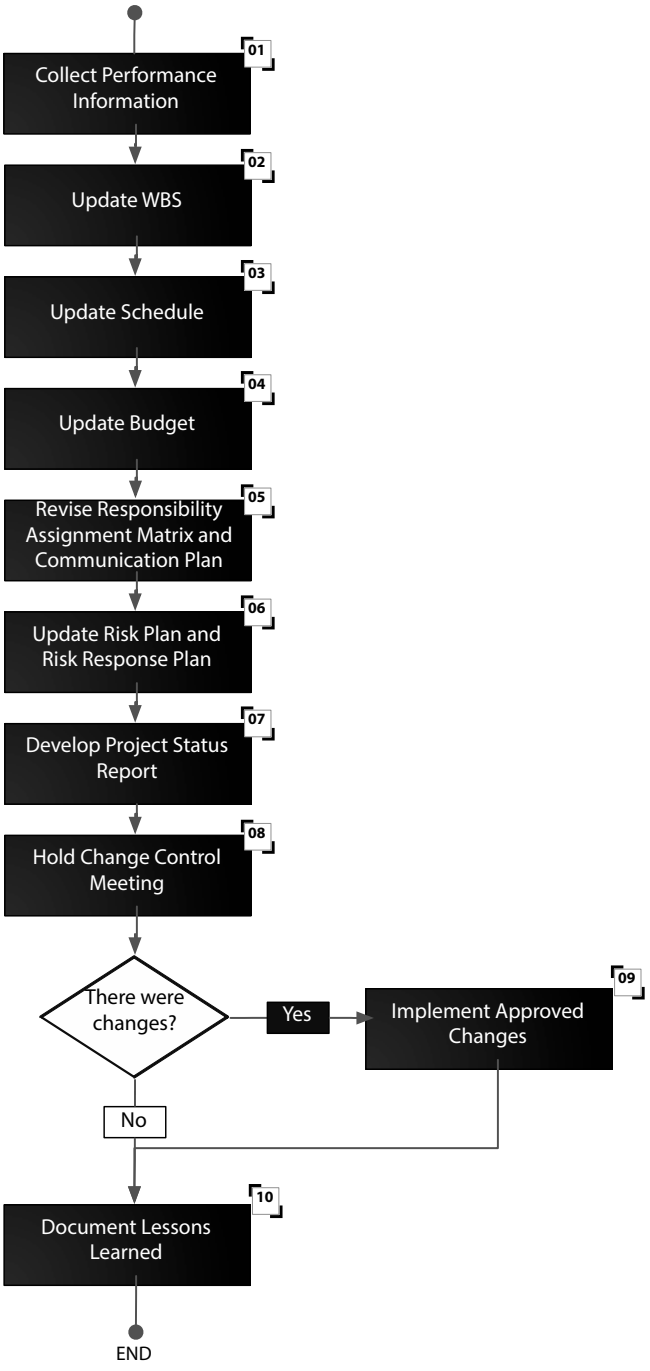

Exhibit 04 – Simplified Flow for the Project Monitoring and Control

1. Collect Performance Information – The goal of this process is to obtain information on the performance of the project with the team, the suppliers, etc. The collection can be done in a structured way or through adaptations and simplifications of agile models, such as parts of the dynamics model for the collection and exchange of information taken at meetings of Daily Scrum of the Scrum model, for example (SCHWABER, 2010). It is important to emphasize that the goal of the process is the collection of information and not decision making.

2. Update WBS – The objective of this process is to update the Work Breakdown Structure (WBS) so that it continues to reflect all deliveries made in the cycle. The remaining work should be evaluated, and the drawing of future deliveries should be performed if necessary. We must pay important attention to the difference between detailing future deliveries and creating new deliveries. The creation of new deliveries that are not expected is a classic case of a sprawl of scope (scope creep) (KUPRENAS & NASR, 2003).

3. Update Schedule – Process that aims to identify the work already done and their deadlines, as well as updates on the WBS, seeking to update the schedule and determine the project deadline. The new timing and deadline will be compared with the approved schedule (baseline) to assess the performance of the project.

4. Update Budget – The objective of this process is to assess the outlay for carrying out the work cycle and update the remaining budget. The new budget will be compared with the approved budget (baseline) to evaluate the performance of the project.

5. Revise Responsibility Assignment Matrix and Communication Plan – The objective of this process is to update the Responsibility Assignment Matrix and Communication Plan. During the implementation of the project changes beyond the responsibilities inherent to the project, there are often roles exchanging and refinements in responsibilities, that causes changes in the Responsibility Matrix. The communication results are evaluated in this process to check if any element of communication needs to be created, deleted or amended in accordance with the behavior of the stakeholders. It aims to ensure that only valid information that supports the decision and the need for information will be produced, avoiding unnecessary stress on the production of useless information.

6. Update Risk Plan and Risk Response Plan – The objective of this process is to update the Risk Plan by identifying new risks and reviewing the already identified risks. The status of existing action plans and the evaluation of their effectiveness are also performed in this process.

7. Develop Project Status Report – The objective of this process is to consolidate all executive information in a simple and straightforward report. The target audience of the report is defined in the Communication Plan and its contents present summary information about the performance of the project cycle and recommendations for change.

8. Hold Change Control Meeting – The objective of this process is to communicate the status of the project cycle, analyze the proposed change requests and decide on their incorporation (or not) to the projects.

9. Implement Approved Changes – Process that aims to incorporate the approved changes to the project plan, including quick review of the documents already developed and appropriated communications about the implemented changes to the stakeholders.

10. Document Lessons Learned – Process that aims to consolidate the lessons learned collected during the last cycle of the project. The lessons contain the record of positive experiences, such as improvements in processes and good management decisions, in addition to the negative experiences that have occurred and the points that should be improved identified during the project.

Assumptions and Success Factors

Developing project plans quickly requires a different environment from the conventional planning. It is crucial to understand some assumptions and success factors to proper understand not only the process but also the results.

Initially, it is important to note that the results obtained with this model are less detailed than those of conventional planning based on the PMBOK ® Guide. This model assumes a reduction in the existing procedures in order to accelerate the development process, and areas of knowledge related to the scope, time, cost, risk and communications were prioritized. This does not mean that other areas are less important.

The documents produced must be simple and straightforward, if there are document templates in the Organization, only their essential fields should be used. It is important to advice that essential is different from important. Essential fields and information are the kind of information that can make the planning not viable if they are not provided. Another advice is to produce the documents using the usual market software such as spreadsheets and texts processors. Integrated and interrelated complex systems increase the ability to control and have many benefits; however, they may not provide the mobility and flexibility required for the accelerated development of the plan.

It is suggested that project planning is performed using the concept of rolling waves (GITHENS, 1998), in order to detail with precision the immediate work and with less accuracy the medium and long term work. These works of medium and long term will be detailed in future update cycles.

Also, quick planning requires a degree of tolerance to risks bigger than the required by the conventional planning (HILSON & MURRAY-WEBSTER, 2005). We can observe, in Exhibit 05, that profiles that have a high degree of discomfort with the uncertainty (Paranoid and Averse) present more difficult to plan, execute and decide on a scenario of urgency due to the high degree of discomfort found in these occasions. Therefore, the proposed process might not fit for all organizations in all cases.

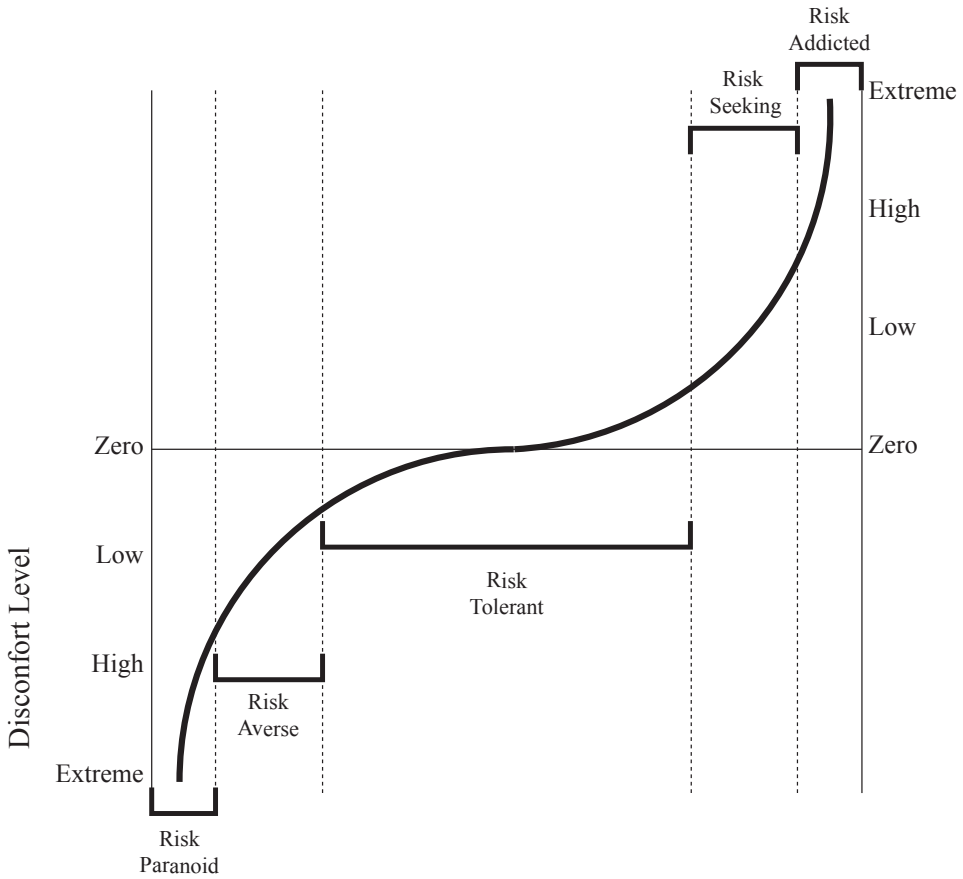

Exhibit 05 – Response to Uncertainty (HILSON & MURRAY-WEBSTER, 2005)

Finally, it is suggested that planning work should be done as a team, following classical models of co-location (or war room), in which the project team works most of the time in the same physical space and keeps in touch face to face (MEARMAN, 2004). This type of work allows a better communication, a reduction in business "silos", an increase in capacity and knowledge sharing in an emergency scenario, and makes the decision process more responsive and effective.

Conclusions

Quick planning aiming to attend the continuous need and the sense of urgency of the organizations is a clear trend in working with projects. In order to satisfy this critical sense of urgency, many projects are implemented without any planning because planning takes time and affects the sense of urgency required.

The proposed model aims to attend this specific scenario, it is a simplification of the planning reality and it does not intended to replace the conventional model of project planning, in which concepts, methods and market standards must be evaluated and structured in the project planning.

When there is a minimum acceptable time for the development of a structured plan, this plan becomes essential and should address in greater detail the knowledge areas outlined in PMBOK ® Guide (PMI, 2008), as well as other concepts and market standards. The use of the proposed model is only recommended when there is no possibility of building a structured plan for the project.

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RICARDO VARGAS

AVOIDING MISTAKES DURING THE TEAM ACQUISITION: ASSIGN THE RIGHT PEOPLE TO THEIR RIGHT FUNCTIONS USING MBTI©

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Abstract

This article presents a vision of the models of preferences presented by the Myers Briggs Type Indicator© (MBTI) and its application for the Staff Acquisition.

Using the comprehension of the relation between the 16 MBTI Types with the main project Management functions, is possible to attribute functions inside the project in concordance with the individual preferences, increasing the motivation of the team and reducing potentials conflicts and problems in the project.

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Team Acquisition in the Project

The project human resources area is one of the PMBOK Guide 3rd (PMI 2004) knowledge areas that the manager and project team have requested more attention.

As reported in the Guide, the Project Human Resources Management includes the processes required to make the most effective use of human resources involved with the project. It includes all project stakeholders: sponsors, customers, individual contributors and others. The main processes are described below and Exhibit 1 provides the mind map of the processes.

- **Human Resources Planning** – Identifying and documenting project roles, responsibilities, and reporting relationships, as well as creating the staffing management plan.
- **Acquire Project Team** – Obtaining the human resources needed to complete the project.
- **Develop Project Team** – Improving the competencies and interaction of team members to enhance project performance.
- **Manage Project Team** – Tracking team member performance, providing feedback, resolving issues, and coordinating changes to enhance project performance.

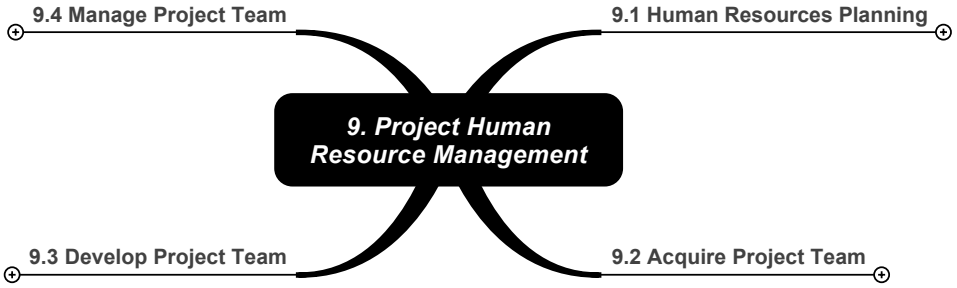

Exhibit 1 – Human Resources Management Processes.

These processes interact with each other and with the process in the other knowledge areas. Each process may involve effort from one or more individuals or groups depending on the needs of the project.

The staff acquisition approached in this paper involves the increase of the capability to find the most adequate professional to each project function (VARGAS, 2004).

Myers-Briggs Type Indicator® (MBTI®)

The purpose of the Myers-Briggs Type Indicator® (MBTI®) personality inventory is to make the theory of psychological types described by C. G. Jung understandable and useful in people's lives. The essence of the theory is that much seeming-

ly random variation in the behavior is actually quite orderly and consistent, being due to basic difference in the way individual prefer to use their perception and judgment.

The Myers-Briggs Type Indicator® was developed by Isabel Briggs Myers and her mother, Katharine Cook Briggs, to make C.G. Jung's theory of psychological type practical and useful in people's lives.

With MBTI® people learn to identify their characteristics, their points of strength and development and the kinds of work more adequate to their type, special abilities and expectations. MBTI® also indicates how relationships and aptness can be developed for personal as well as for organizational success.

MBTI® further indicates:

- How to improve interpersonal relationships
- How to improve the ability to lead with efficiency
- How to deepen self-knowledge
- How to create more productive and participating work teams
- How to endow your organization with higher patterns of efficiency and productivity.

The MBTI ® test is applied by CPP (Center for Applications of Psychological Type) through a questionnaire with 93 multiple choice questions, tabulated through a data bank with millions of people who have already used MBTI®. The result is presented with 4 letters that picture the exercise of the individual preferences regarding perception and judgment, as follows:

- **E or I** – Where the person prefers to focus his/her attention (Extroverts or Introverts)
- **S or N** – How the person obtains information about things (Sensors or Intuitives)
- **T or F** – How the person takes decisions (Thinking or Feeling)
- **J or P** – How the person guides him/herself regarding the world (Judging or Perceiving)

The Internet has a series of tests available to MBTI®, such as the sites http://www.humanmetrics.com and http://bloginality.love-productions.com .

The Sixteen Types[1]

[1] Excerpted from Introduction to Type by Isabel Briggs Myers published by CPP. Inc

By combining the individual preferences we have the sixteen psychological Types. Isabel Briggs Myers has prepared a basic set of characteristics for each of these types, as will be presented below.

		SENSORS		INTUITIVES			
		With Thinking	With Feeling		With Thinking		
INTROVERTS	Judging	ISTJ	ISFJ	INFJ	INTJ	Judging	EXTRAVERTS
	Perceiving	ISTP	ISFP	INFP	INTP	Perceiving	
EXTRAVERTS		ESTP	ESFP	ENFP	ENTP		INTROVERTS
	Judging	ESTJ	ESFJ	ENFJ	ENTJ	Judging	

Exhibit 2 – Sixteen Psychological Types (©Consulting Psychologists Press Inc.).

ISTJ - Quite, serious, earn success by thoroughness and dependability. Practical, matter-of-fact, realistic, and responsible. Decide logically what should be done and work toward it steadily, regardless of distractions. Take pleasure in making everything orderly and organized – their work, their home, their life. Value traditions and loyalty.

ISFJ - Quiet, friendly, responsible, and conscientious. Committed and steady in meeting their obligations. Thorough, painstaking, and accurate. Loyal, considerate, notice and remember specifics about people who are important to them, concerned with how others feel. Strive to create an orderly and harmonious environment at work and at home.

INFJ - Seek meaning and connection in ideas, relationships, and material possessions. Want to understand what motivates people and are insightful about others. Conscientious and committed to their firm values. Develop a clear vision about how best to serve the common good. Organized and decisive in implementing their vision.

INTJ - Have original minds and great drive for implementing their ideas and achieving their goals. Quickly see patterns in external events and develop long-range explanatory perspectives. When committed, organize a job and carry it through. Skeptical and independent, have high standards of competence and performance – for themselves and others.

ISTP - Tolerant and flexible, quiet observers until a problem appears, then act quickly to find workable solutions. Analyze what makes things work and readily get through large amounts of data to isolate the core of practical problems. Interested in cause and effect, organize facts using logical principles, value efficiency.

ISFP - Quiet, friendly, sensitive, and kind. Enjoy the present moment, what's going on around them. Like to have their own space and to work within their own time frame. Loyal and committed to their values and to people who are important to them. Dislike disagreements and conflicts; do not force their opinions or values on others.

INFP - Idealistic, loyal to their values and to people who are important to them. Want an external life that is congruent with their values. Curious, quick to see possibilities, can be catalysts for implementing ideas. Seek to understand people and to help them fulfill their potential. Adaptable, flexible, and accepting unless a value is threatened.

INTP - Seek to develop logical explanations for everything that interests them. Theoretical and abstract, interested more in ideas than in social interaction. Quiet, contained, flexible, and adaptable. Have unusual ability to focus in depth to solve problems in their area of interest. Skeptical, sometimes critical, always analytical.

ESTP - Flexible and tolerant, they take a pragmatic approach focused immediate results. Theories and conceptual explanations bore them – they want to act energetically to solve the problem. Focus o n the here-and-now, spontaneous, enjoy each moment that they can be active with others. Enjoy material comforts and style. Learn best through doing.

ESFP - Outgoing, friendly, and accepting. Exuberant lovers of life, people, and material comforts. Enjoy working with others to make things happen. Bring common sense and a realistic approach to their work, and make work fun. Flexible and spontaneous, adapt readily to new people and environments. Learn best by trying a new skill with other people.

ENFP - Warmly enthusiastic and imaginative. See life as full of possibilities. Make connections between events and information very quickly, and confidently proceed based on the patterns they see. Want a lot of affirmation from others, and readily give appreciation and support. Spontaneous and flexible, often rely on their ability to improvise and their verbal fluency.

ENTP - Quick, ingenious, stimulating, alert, and outspoken. Resourceful in solving new and challenging problems. Adept at generating conceptual possibilities and then analyzing them strategically. Good at reading other people. Bored by routine, will seldom do the same thing the same way, apt to turn to one new interest after another.

ESTJ - Practical, realistic, matter-of-fact. Decisive, quickly move to implement decisions. Organize projects and people to get things done, focus on getting results

in the most efficient way possible. Take care of routine details. Have a clear set of logical standards, systematically follow them and want others to also. Forceful in implementing their plans.

ESFJ - Warmhearted, conscientious, and cooperative. Want harmony in their environment; work with determination to establish it. Like to work with others to complete tasks accurately and on time. Loyal, follow through even in small matters. Notice what others need in their day-by-day lives and try to provide it. Want to be appreciated for who they are and for what they contribute.

ENFJ - Warm, empathetic, responsive, and responsible. Highly attuned to the emotions, needs, and motivations of others. Find potential in everyone, want to help others fulfill their potential. May act as catalysts for individual and group growth. Loyal, responsive to praise and criticism. Sociable, facilitate others in a group, and provide inspiring leadership.

ENTJ - Frank, decisive, assume leadership readily. Quickly see illogical and inefficient procedures and policies, develop and implement comprehensive systems to solve organizational problems. Enjoy long-term planning and goal setting. Usually well informed, well read, enjoy expanding their knowledge and passing it on to others. Forceful in presenting their ideas.

Project Management Functions Related with Psychological Types

Based in the psychological types presented by the MBTI® it can be proven that in an environment of projects, each one of the types has determined inherent easinesses and difficulties to the work in projects.

Based in the work of KROEGER, THUESEN, J. M. & RUTLEGE, H. (2002), can be consolidated the following aspects of each type: Workplace Contribution, Pathway to the Professional Growth, Leadership Qualities, Team Spirit and suggested PM. Jobs.

ISTJ

- **Workplace Contribution** – Establishes order dutifully and steadily and works within the system to manage and complete tasks on time and under budget.
- **Pathway to Professional Growth** – Must learn that both organizational change and people issues – ideas that may violate tradition – can play powerful and positive roles in organizational life.
- **Leadership Qualities** – Brings tasks to completion efficiently and dutifully while maintaining respect and order throughout the group or organization.
- **Team Spirit** – Teams, if well managed, are a good way to distribute tasks

and complete projects, but the important work that is done is carried out by individuals when the team meetings are over.

- **Suggested PM Job –** financial work, controlling, technical problem solving, individual and isolated tasks.

ISFJ

- **Workplace Contribution –** Offers quiet support, a sense of order, and attention to detail from behind the scenes.
- **Pathway to Professional Growth –** Must learn to be open to new possibilities and changing situations—-this flexibility can often be the support someone most needs.
- **Leadership Qualities –** Produces results through one-on-one relationships and detail control and tends to perform tasks oneself rather than delegate.
- **Team Spirit –** Teams are worthwhile work units, vital and important structures that are yet another arena in which to provide quiet, unassuming support to the organization and its people.
- **Suggested PM Job –** one to one relationship, tasks with no delegation, idea generation.

INFJ

- **Workplace Contribution –** Turns work into a cause and injects—with quiet, serious focus – inspiration and devotion throughout the organization.
- **Pathway to Professional Growth –** Must learn that his or her excitement about the future and the possibilities it holds for people is often overlooked, buried as it is beneath a serious exterior.
- **Leadership Qualities –** Provides inspirational and visionary direction with a moralistic or values-related spin, working with focus toward change and development.
- **Team Spirit –** Teams are complex human systems that need understanding and care and that, if well managed, can produce inspirational, valuable work.
- **Suggested PM Job –** idea inspiration, visionary tasks and project management, work well with complex situations.

INTJ

- **Workplace Contribution –** Provides organizations and groups with objective clarity, vision, and strategic thinking white driving toward change and improvement.
- **Pathway to Professional Growth –** Must learn that each idea for visionary change brings with it untold details to which someone will need to tend – the stresses brought on by visionary change are real and painful.
- **Leadership Qualities –** Draws energy from the complexity of future possibilities and shepherds individuals and groups through uncertainty and change with decisiveness and fairness.
- **Team Spirit –** Teams are powerful and complicated systems that, if well designed and managed, can play a pivotal role in bringing a group or organi-

zation's vision to fruition.

- **Suggested PM Job** – strategic problem-solving, able to work with details and with uncertainty, group organization.

ISTP

- **Workplace Contribution** – Solves problems practically and immediately with a calm, clear-thinking resolve.
- **Pathway to Professional Growth** – Must learn that the complexity of people and relationships deserves consideration and offers no quick fix.
- **Leadership Qualities** – Sets an example to act independently and to attend to the needs of the short term, unencumbered by tradition, procedure, or the demands of others.
- **Team Spirit** – Teams are often an irritation and a diversion from effective, practical work, work that is best done alone.
- **Suggested PM Job** – conflict resolution with calm and control, immediate action tasks, work well alone, practical and direct project tasks.

ISFP

- **Workplace Contribution** – Support people and their efforts with a gentle – almost anonymous – attention to details and action in the moment.
- **Pathway to Professional Growth** – Must learn to focus on the patterns and problems beyond immediate concern – to look for and confront the systemic or root issues and not to get lost in the foreground, solving only the problems of today.
- **Leadership Qualities** – Leads by example-by tending to task details and providing gentle; unassuming support.
- **Team Spirit** – Teams are fine and can be fun, through they are personally draining and intrusive; quiet support and diligent works are what make teams effective.
- **Suggested PM Job** – hidden project tasks, tasks that must be done without reward, quiet support.

INFP

- **Workplace Contribution** – Holds and protects the values within which are rooted individual, group, and organizational identities —often serving as moral ballast for organizations and teams.
- **Pathway to Professional Growth** – Must learn to face conflict and confront it in the moment.
- **Leadership Qualities** – Appeals to values through personal relationships – controlling tasks and people in such a way that those concerned do not notice they are being controlled at all.
- **Team Spirit** – Though teamwork is difficult and draining, collaborating and working together to pool resources and ideas is valuable and motivating.
- **Suggested PM Job** – team support, intuitive jobs, team moral ballast.

INTP

- **Workplace Contribution** – Uses cleverness and independent thinking to problem-solve and reinvent, and in an easygoing unassuming manner prods organizational change and improvement.
- **Pathway to Professional Growth** – Must learn that connecting and communicating with other people is important – great solutions and ideas are adopted and enacted through personal relationships.
- **Leadership Qualities** – Creates and works toward a vision and a better solution and allows others to follow at their own pace and ability.
- **Team Spirit** – A team is okay if it allows members to enter on their own terms and to contribute in their own way – but the best visioning and problem solving is done in isolation.
- **Suggested PM Job** – valorize each contribution in a team, isolated problem-solving, technical project job, financial control.

ESTP

- **Workplace Contribution** – Goes with the flow, adapts to the unexpected, allows variables, and delivers what needs to be delivered.
- **Pathway to Professional Growth** – Must learn to be patient with routines and to be aware that others may find comfort in structure, rules, and contemplation of future possibilities.
- **Leadership Qualities** – Keeps oneself and others on their toes by being open and responsive to the unexpected and abandoning rules of hierarchy and tradition in the name of expediency.
- **Team Spirit** – Teams can be fun; however, without constant action and variation, or in dull meetings, they can run aground.
- **Suggested PM Job** – work well with unpredictable job, without hierarchy and tradition.

ESFP

- **Workplace Contribution** – Provides high-spirited energy that keeps a variety of people and actions moving in positive ways.
- **Pathway to Professional Growth** – Must learn to stretch to face the negative, stressful, and even hostile moments of work life is not always a barrel of fun.
- **Leadership Qualities** – Has a personal and often playful go-with-the-moment style that can be highly motivating to others.
- **Team Spirit** – Teamwork is the best way to approach any endeavor; the entire world's a team, and only good can come from such joined efforts.
- **Suggested PM Job** – diverse cultural team manager, group problem-solving, global project management.

ENFP

- **Workplace Contribution** – Motivates and invigorates thought inspiration, enthusiasm, and unyielding attention to personal relationships.

- **Pathway to Professional Growth** – Must learn to follow projects and commitments through to completion and to be aware that one's wide mood swings can frustrate and confuse those with whom he or she works.
- **Leadership Qualities** – Motivates, inspires, and cajoles people to accomplish tasks and to develop both personally and professionally.
- **Team Spirit** – Teams are fun and energizing – especially when conflict, hierarchy, and tight time lines can be avoided.
- **Suggested PM Job** – team motivator, group problem-solving, optimistic team leader that believe that work together is the best work.

ENTP

- **Workplace Contribution** – Regards the workplace as a system to be moved, challenged, and reconfigured so that learning is constant and worthwhile tasks are accomplished.
- **Pathway to Professional Growth** – Must learn to focus energy on follow-through and completion – even when one deems them boring and to remember that wide mood swings can send mixed signals.
- **Leadership Qualities** – Empowers oneself and others by challenging, confronting, and even taking an opposing point of view to enhance each individual's contribution to the end result.
- **Team Spirit** – Teams are one more important vehicle for earning – an arena for testing ideas, discussing differences, and collaborating on results.
- **Suggested PM Job** – change management, change leader, conflict resolution from opposing points of view.

ESTJ

- **Workplace Contribution** – Drives to take charge, to see the practical facilitation of a task, and to complete it with dispatch and skill.
- **Pathway to Professional Growth** – Must learn to be less hard-charging by listening to and allowing alternative viewpoints.
- **Leadership Qualities** – Takes charge, demands 1oyalty, pushes hard to accomplish a task, and tells it like it is.
- **Team Spirit** – Teams are an effective tool for accomplishing tasks as long as they are well managed and people's roles and goals are defined.
- **Suggested PM Job** – practical team manager, quick answer problem-solving, role management, execution manager.

ESFJ

- **Workplace Contribution** – Builds a harmonious environment that supports personal achievement and task accomplishment.
- **Pathway to Professional Growth** – Must learn to accept differences, allow them to be expressed, and recognize that conflict is not always destructive.
- **Leadership Qualities** – Projects inspiration and graciousness with a constant yet gentle nudge toward task completion.
- **Team Spirit** – Teams are good and can be productive; however, arguments and disagreements should not be tolerated.

- **Suggested PM Job** – harmonious team manager, good supporting individual tasks, do not accept intolerances from the team members.

ENFJ

- **Workplace Contribution** – Personally inspires and motivates all to work harmoniously for the common good.
- **Pathway to Professional Growth** – Must learn that not all situations need rescue and that disagreements are not personal attacks.
- **Leadership Qualities** – Empowers others to accomplish what needs to be done by nurturing relationships and making personal appeals.
- **Team Spirit** – Teams are good, people are good, and work is good when the theme of togetherness drives the task.
- **Suggested PM Job** – positive team leader, optimistic point of view, nurture relationships, conflict resolution from team members.

ENTJ

- **Workplace Contribution** – Through hard-charging arguments and action, intellectually inspires and challenges everyone to experience a vision and to move toward its fulfillment with dispatch.
- **Pathway to Professional Growth** – Must learn to allow time for others to develop at their own pace and level of commitment.
- **Leadership Qualities** – Is task-driven and demanding, with a motivational spin for everyone to get on board and move toward achieving the goal.
- **Team Spirit** – Teams can be good and do provide opportunities for more involvement – as long as the task is completed and the group's process do not slow or water down the vision.
- **Suggested PM Job** – intuitive team leader, intellectual leader, task driven manager.

Conclusions

The aim of this article is to associate the theory proposed by C. G. Jung and the need to accomplish a judicious and well-succeeded human resources selection for the project. With the allocation of the psychological types that are aligned to the functions they will represent, the probability of turn-over is reduced, thus increasing the motivation and facilitating the development of the team. Finally, it is important to stress that there is not a better or worse type. All types have strong and weak features, and, in a project's human resources selection, several other factors, dynamics and processes will complement MBTI® in the adequate selection and allocation of the project's resources.

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RICARDO VARGAS

A NEW APPROACH TO PMBOK® GUIDE 2000

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Nashville – Tennessee – USA – 2001

Abstract

This work puts forward a new approach to PMBOK® Guide in which the thirty-nine processes are organized in five groups: initiation, planning, executing, controlling and closing process. This arrangement suggests a chronologically structured, more didactic view, which has been successfully tested in two PM classes in Brazil, instead of the former organization in nine Knowledge Areas. This approach is also useful to PMP exam preparation where two hundred questions are divided into process groups rather than knowledge areas.

Related Podcasts

♫ The New PMBOK® Guide 5th Edition
http://rvarg.as/5q

♫ The new PMBOK Guide – 4th Edition
http://rvarg.as/bb

Related Document

PMBOK® 5th Edition Processes Flow
http://rvarg.as/p5ed

PMBOK® Guide 2000

The PMBOK® Guide is nowadays the most important reference document about the Project Management Body of Knowledge. It was defined in 1987 as "all those topics, subject areas and intellectual processes which are involved in the application of sound management principles to ... projects". The guide is distributed by PMI, free of charge, with more than 640,000 copies placed in circulation worldwide (March 2001). As established in the guide, "the primary purpose of this document is to identify and describe that subset of the PMBOK® which is generally accepted. Generally accepted means that the knowledge and practices described are applicable to most projects of the time, and that there is widespread consensus about their value and usefulness" (PMBOK® Guide, 2000 Edition). According to the purpose of the guide, it is essential to have a logical and coherent organization directly aimed at the process groups in order to facilitate the understanding of the chronology of Project Management processes (Exhibit 01). However, it does not mean that the knowledge areas should be considered of less importance, as they are crucial for the understanding of the multidisciplinary mechanisms related to project management.

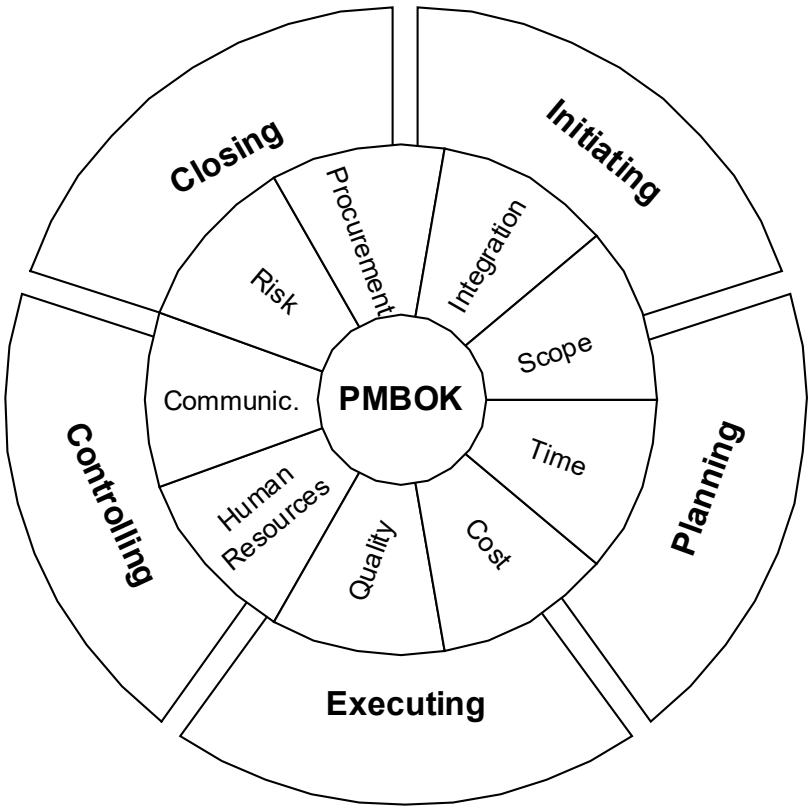

Exhibit 1 – PMBOK® based on knowledge areas as opposed to PMBOK® based on processes groups.

Project Management Process Groups

The PMBOK® Guide organizes the Project Management Processes in five groups: initiating processes, planning processes, executing processes, controlling processes and closing processes. All thirty-nine processes are divided into these five groups and intertwined by the results that they achieve (Exhibit 02). The fact that the five process groups are also interlinked creates a dynamic net of processes that are repeated and combined in each phase of the project , and consequently originates a process which is not discrete and overlaps itself in different phases and levels of the project.

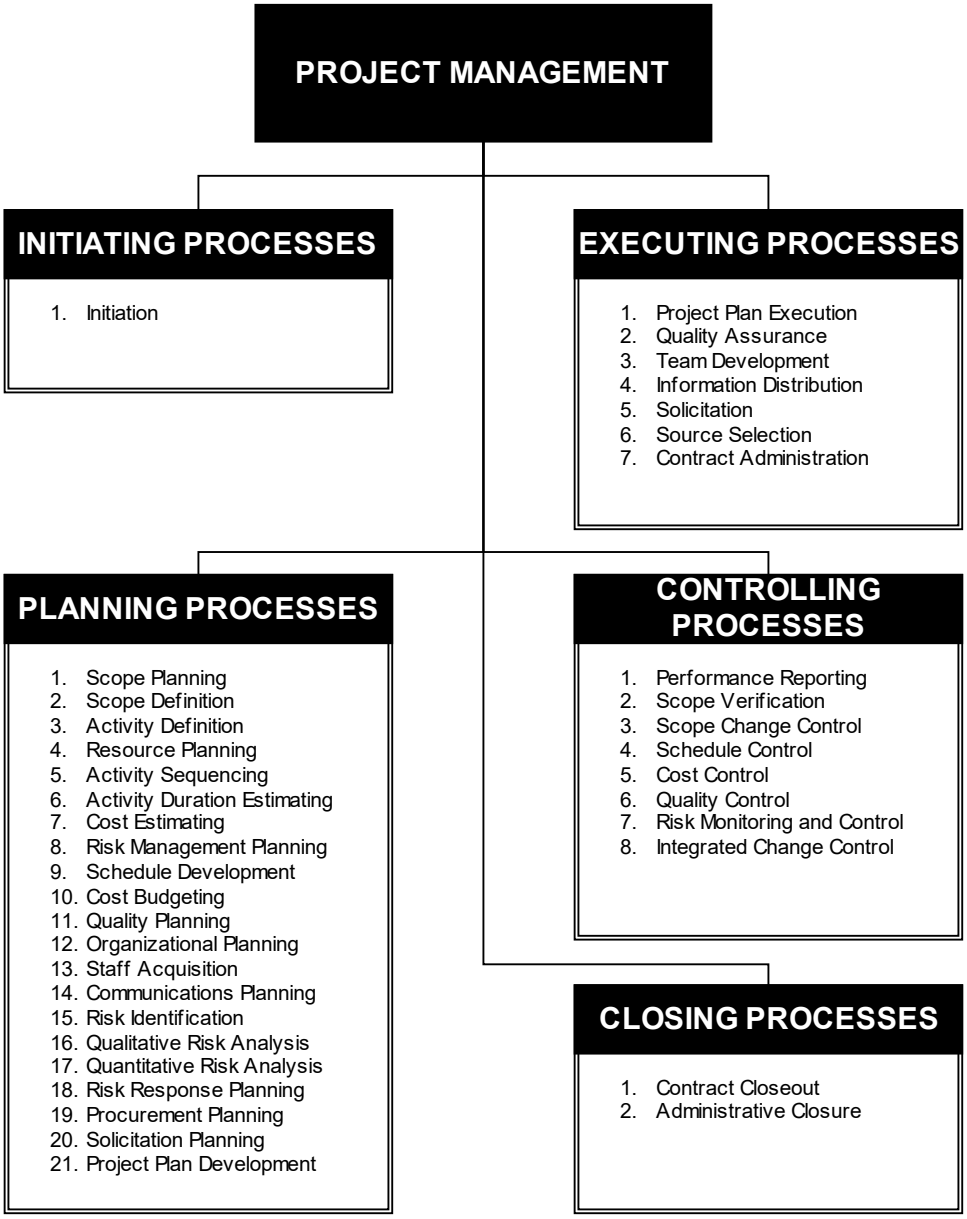

Exhibit 2 – Thirty-nine processes divided into five groups.

New Structure of PMBOK® Guide

The PMBOK® Guide suggested here redefines and reorders the processes in new chapter groups. The first two chapters of part 1 (The Project Management Framework) are unchanged. A chapter 3 is now built from the introductions of the nine chapters of the second part, relating each of the knowledge areas and its principal processes, without detailing any process. The previous chapter 3, which describes the processes of administration, will now be chapter 4 and will be in the second part of the guide called "The Project Management Process Groups". All thirty-nine processes will have now been distributed in agreement with the phases of the project in which they are used.

The greatest change would be to place the introductory chapters of each knowledge area in a third chapter which gives an overall view of all the processes within each area. The former chapter 3 then becomes chapter 4, providing details about Project Management process groups. However, the specification of each process group (initiating, planning, executing, controlling and closing), which used to be denominated 3.3.X, becomes the introduction of chapters 5 to 9. The new table of contents is systematized below:

Section I - The Project Management Framework

Chapter 1 Introduction

1.1. Purpose of This Guide

1.2. What is a Project?

1.3. What is Project Management?

1.4. Relationship to Other Management Disciplines

1.5. Related Endeavors

Chapter 2 Project Management Context

2.1. Project Phases and the Project Live Cycle

2.2. Project Stakeholders

2.3. Organizational Influences

2.4. Key General Management Skills

2.5. Social-Economic-Environmental Influences

Chapter 3 Project Management Knowledge Areas

3.1. Project Integration Management

3.2. Project Scope Management

3.3. Project Time Management

3.4. Project Cost Management

3.5. Project Quality Management

3.6. Project Human Resource Management

3.7. Project Communications Management

3.8. Project Risk Management

3.9. Project Procurement Management

Section II - The Project Management Process Groups

Chapter 4 Project Management Process

4.1. Project Processes

4.2. Process Groups

4.3. Process Interactions (introduction only)

4.4. Customizing Process Interactions

4.5. Mapping of Project Management Process

Chapter 5 Initiating Process

5.1. Initiation

Chapter 6 Planning Process

6.1. Scope Planning

6.2. Scope Definition

6.3. Activity Definition

6.4. Resource Planning

6.5. Activity Sequencing

6.6. Activity Duration Estimating

6.7. Cost Estimating

6.8. Risk Management Planning

6.9. Schedule Development

6.10. Cost Budgeting

6.11. Quality Planning

6.12. Organizational Planning

6.13. Staff Acquisition

6.14. Communications Planning

6.15. Risk Identification

6.16. Qualitative Risk Analysis

6.17. Quantitative Risk Analysis

6.18. Risk Response Planning

6.19. Procurement Planning

6.20. Solicitation Planning

6.21. Project Plan Development

Chapter 7 Executing Process

7.1. Project Plan Execution

7.2. Quality Assurance

7.3. Team Development

7.4. Information Distribution

7.5. Solicitation

7.6. Source Selection

7.7. Contract Administration

Chapter 8 Controlling Process

8.1. Performance Reporting

8.2. Scope Verification

8.3. Scope Change Control

8.4. Schedule Control

8.5. Cost Control

8.6. Quality Control

8.7. Risk Monitoring and Control

8.8. Integrated Change Control

Chapter 9 Closing Process

9.1. Contract Closeout

9.2. Administrative Closure

Section III - Appendices

Section IV – Glossary and Index

With this table of contents a new PMBOK® can easily be built beginning with the reordering of the conventional processes without losing any part of the original, that is, without the omission of any of the original content.

Process Interactions

All 39 processes are linked by their inputs and outputs. In the New Approach to PMBOK® Guide the system for numbering the processes serves to focus on the process groups and not the knowledge areas. This makes the focus of each of the processes continuous for a period of time while it is not necessarily linked to one of the nine knowledge areas.

The numeration of the inputs, tools and techniques and outputs of the conventional PMBOK® is given according to a sequence of numerals in which the first number of the sequence represents the knowledge area, the second number, the sequence of the process within the knowledge area, the third, the type of data (inputs, tools and techniques or outputs) and the fourth is the sequential of data within the type (Exhibit 03).

TEMPLATE	**EXAMPLE**
A . B . C . D	**4.1.2.1 Project planning methodology**
A - Knowledge Area 4 - Integration 5 - Scope 6 - Time 7 - Cost 8 - Quality 9 - Human Resources 10 - Communications 11 - Risks 12 - Procurement	**A - Knowledge Area** 4 - Integration
B - Process Number inside each Knowledge Area 1 (first) to 6 (only in Risks and Procurement areas)	**B - Process Number inside each Knowledge Area** 1 - First Integration Process
C - Data Type 1 - Input 2 - Tools and Technique 3 - Output	**C - Data Type** 2 - Tools and Technique
D - Data Number inside each Data Type 1 to 10	**D - Data Number inside each Data Type** 1 - First Tool and Technique

Exhibit 3 – Nomenclature of the conventional PMBOK® and example of the first Tools and Techniques of the Integration Process "Project Plan Development" denominated "Project planning methodology".

In the New Approach to PMBOK® Guide, the numeration of the inputs, tools and techniques and outputs is given by a sequence of numerals similar to that of the conventional PMBOK®, although the first number of the sequence represents the process group, the second number, the sequence of the process within the process group, the third, the type of data (inputs, tools and techniques or outputs) and the fourth is the sequential of the data within the type(Exhibit 04 and 05).

TEMPLATE	EXAMPLE
X . Y . C . D - Process data	**6.21.2.1 - Project planning methodology**
X - Process Group	**X - Process Group**
5 - Initiating Process 6 - Planning Process 7 - Executing Process 8 - Controlling Process 9 - Closing Process	6 - Planning Process
Y - Process Number inside each Process Group	**Y - Process Number inside each Knowledge Area**
1 (first) to 21 (Planning Process)	21 - Twenty-First Planning Process (last)
C - Data Type	**C - Data Type**
1 - Input 2 - Tools and Technique 3 - Output	2 - Tools and Technique
D - Data Number inside each Data Type	**D - Data Number inside each Data Type**
1 to 10	1 - First Tool and Technique

Exhibit 4 – Nomenclature of the New Approach to PMBOK® Guide and example of the first Tools and Techniques of the Integration Process "Project Plan Development" denominated "Project planning methodology".

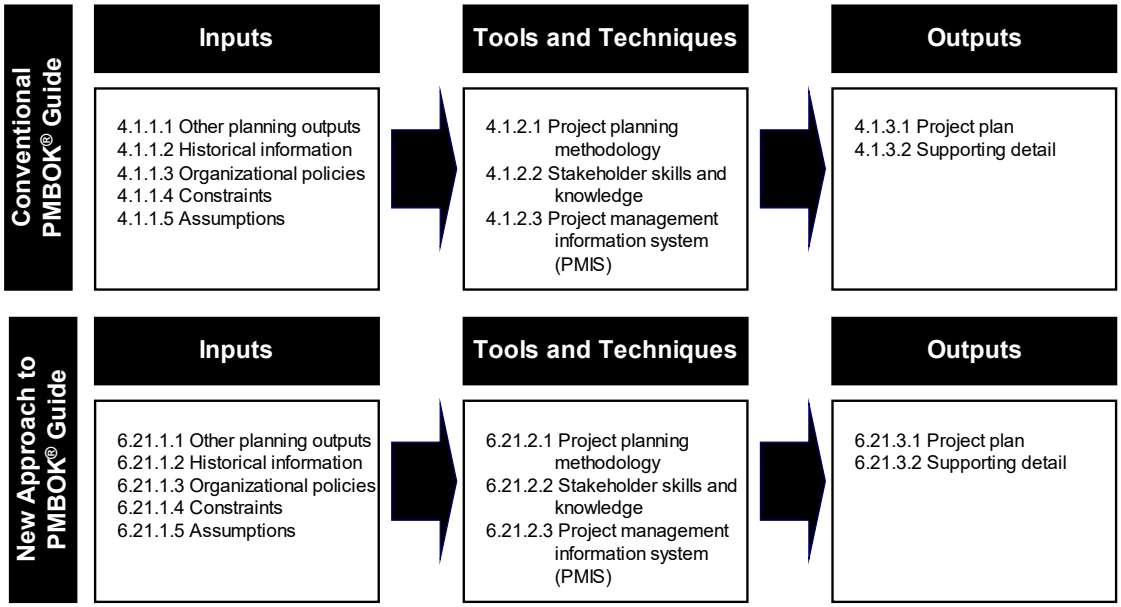

Exhibit 5 – Example of the new numbering system for inputs, tools and techniques and outputs for the Integration Process "Project Plan Development" and a comparison with the conventional PMBOK® numbering system.

Results Achieved in Pilot Training Courses Using the New Structure

With a view to evaluating the New Approach to PMBOK® Guide, an experiment with two thirty-student classes of Project Management was held in a multinational IT company in Brazil, according to the specifications below:

- 100% of the evaluated participants belonged to the same company
- 80% of the participants in each group were engineers (24 in each group)
- 20% of the participants in each group had a degree in Administration (06 in each group)
- 100% of the participants were unaware of the existence of PMBOK® Guide and considered their knowledge of Project Management to be low or null.

The instructor was the same for both classes and the time and weekdays of the training were the same for both with a lag of 1 week between the classes. The instructor prepared a very similar teaching methodology for each of the two groups, including the same exercises and tests.

In order to select the participants for each group, an equal division based on their professional backgrounds was part of the chosen procedure. A forty question test covering Project Management in general was also applied for the purpose of having groups as homogeneous as possible and therefore avoiding flaws in the evaluation. Each group attended a 32-hour training program covering the PMBOK® processes with no absence. The first group's course followed the approach and order of the conventional PMBOK® in which the subjects are divided into knowledge areas, whereas the second group was exposed to the New Approach to PMBOK®, having the subjects divided into processes.

At the end of the program a new forty-question test on Project Management was administered to the two groups. The results achieved were as follows:

Group A - Conventional PMBOK® Guide

- Average: 26.97
- Standard Deviation: 3.56 (13.2%)
- Highest score: 32
- Lowest score: 22
- Median: 26.5
- Mode: 26

Group B - New Approach to PMBOK® Guide

- Average: 32.63
- Standard Deviation: 2.51 (7,70%)
- Highest score: 37

- Lowest score: 28
- Median: 33
- Mode: 30

The evaluation results suggest that The New Approach to PMBOK® led to an increase of about 20% in the final scores, with lower standard deviation. They also suggest significant gains when taken into consideration the questionnaire filled out by the participants, which reveals that the major difficulty concerning the present PMBOK® is its analytical structure aimed at being used as reference material rather than as a means of initial learning.

After the results had been tabulated, all participants were invited to evaluate the two versions as a group. This evaluation shows that the New Approach to PMBOK® holds the following advantages:

- It makes the reading of PMBOK® sequential, avoiding explaining and analyzing future process groups in previous phases of the guide.
- The visualization of the relation between the processes becomes easier as the new structure clearly identifies the relation between certain succeeding process inputs and previous process outputs.
- The new structure does not leave out any of the content or standards previously established by the original PMBOK® Guide.

These results suggest an apparent gain according to the scores obtained by these participants, although the study must be deepened with other groups and other companies to produce a working result that is more scientifically proven.

Conclusions

This New Approach to the PMBOK® Guide does not come as a substitute for the original PMBOK® Guide, but as a new view of the processes. Its objective is to facilitate professional learning of the Project Management Body of Knowledge. Professionals who are not familiar with Project Management and those who are preparing for the PMP exam are the target public of the suggested approach. A unique problem must be considered in regard to the numbering system. In the New Approach to the PMBOK® Guide, all of the entrance elements, tools, and exits for each process are numbered according to the phase of the project and not according the knowledge area, which could create some discomfort in those professionals who already know and use the conventional PMBOK® Guide with a certain level of confidence.

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RICARDO VARGAS

MANAGING AN ERP IMPLEMENTATION PROJECT USING BASIC SOFTWARE TOOLS AND WEB BASED SCHEDULING CONTROL

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III European Project Management Conference
Jerusalem – Israel – 2000

PMI Global Congress 1999 - North America
Philadelphia – Pennsylvania – USA – 1999

Abstract

This paper presents a fast, inexpensive and safe process to plan and monitor ERP implementation processes like SAP R3. Based in concrete experiences at industrial unities of multinational companies, the process is considered simple and effective to control this kind of dynamic projects.

Related Podcasts

♫ Software Development Projects: Are There Too Many Tribal Chiefs to Few Indians?
http://rvarg.as/5n

♫ 3 Factors that make an Information Technology Project different from the other Projects
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♫ How to keep the Stakeholders informed about the Project Deliverables: The Secret of the Milestones
http://rvarg.as/b4

♫ Measuring the Physical Progress of the Project
http://rvarg.as/8f

(ERP) Enterprise resource planning

The systems for Enterprise Resource Planning, known as ERP, are a set of interdependent elements organized into a single and complex whole that seeks to capture and globally manage the business. Due to the complexity of the implementation and to the dynamics of the business environment, it is necessary to ensure that the deadlines, the scope, and the costs of the projects are guaranteed, with the lowest cost control possible. The main stages of the process are described below, with suggestions for fast, inexpensive and safe implementation, based on our concrete experience at industrial units of multinational companies.

The main processes are:

- Team division and stratification.
- Implementation Methodology, Definition of Scope and Deadlines
- Preparation of Network Environment and Creation of Resource Pool
- Definition of the Web Environment
- Consolidating the Macro Project and Integrated Management

®Team division and stratification

The first step in the solution is to stratify the teams, taking as a base the Communications Planning and the company organizational structure. Three levels are created for the project control. They are: production, production management, and coordination (Exhibit 1).

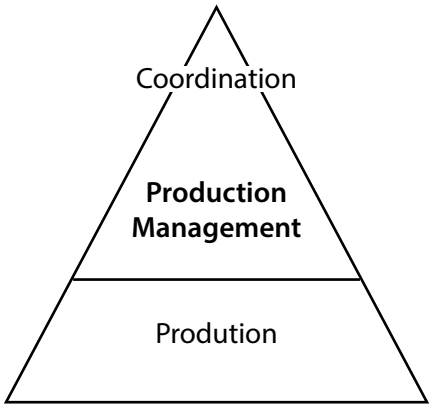


Exhibit 1 – Team stratification for project control

Implementation Methodology, Definition of Scope and Deadlines

Most of the time the methodology to be used in the implementation is that developed by the actual software manufacturer, such as ASAP for SAP R3 (Exhibit 2).

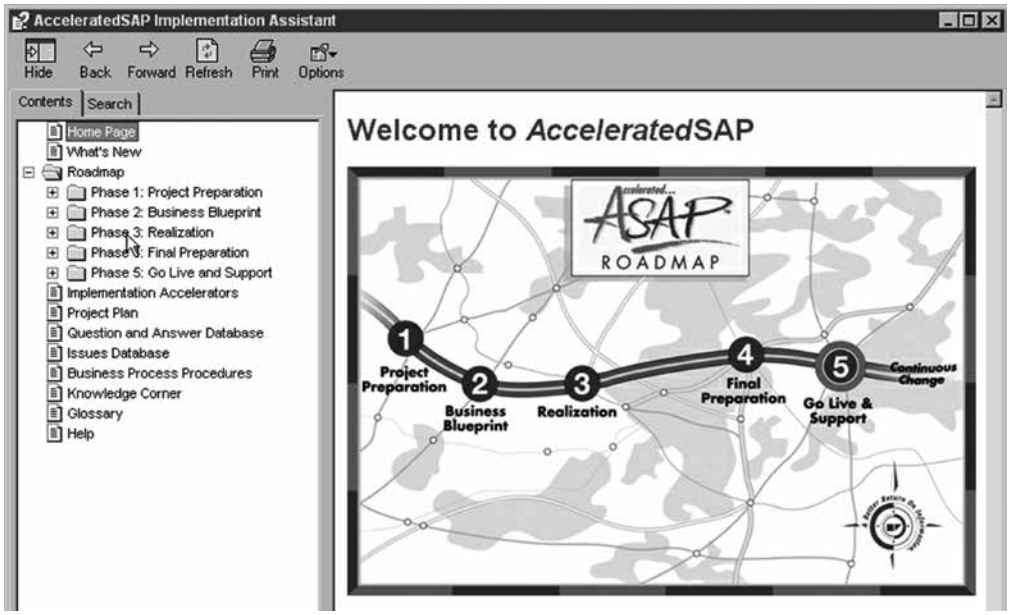


Exhibit 2 – Accelerated SAP Implementation Assistant for project scope definition.

The level of detail of the methodology, which will be universally applied in all of the modules, should be defined together with the implementers, as well as structuring the generic content of the work that will be controlled by the project, and creating a basic Work Breakdown Structure for all of the modules.

From there, each module is detailed until the work packages are established. The work packages are controlled by the project teams themselves and, upon being completed, reflect the execution of the methodology activity.

The group, using mainly the expert judgment of consultants and implementers, determines the deadlines for each work package. A fundamental consideration is the simultaneous execution of the methodology activities in each module. For example, the prototyping of the financial and production planning, etc., should be carried out in parallel. If a module has completely different features from the rest, which impedes it from fitting in with the standard methodology, it will be developed separately and consolidated after the other modules, as is the case of the Basis group of SAP R3 (Exhibit 3).

<table>
<tr><td colspan="4">GLOBAL PROJECT</td></tr>
<tr><td rowspan="5">Accelerated SAP</td><td>Sales and Distribution (SD)</td><td rowspan="5">ABAP 4</td><td rowspan="5">Basis and IT</td></tr>
<tr><td>Material Management (MM)</td></tr>
<tr><td>Production Planning (PP)</td></tr>
<tr><td>Finance (FI)</td></tr>
<tr><td>Controlling (CO)</td></tr>
<tr><td colspan="4">RESOURCE POOL</td></tr>
</table>

Exhibit 3 – Structure of Implementation in Parallel and objects for Global Project.

Preparation of Network Environment and Creation of Resource Pool

Parallel to the group work in the modules, a computer network infrastructure is created for remote management. Taking advantage of the computers made available for the project team, a set of directories is created at the server, which will file the projects relative to each group in distinct folders, with access control possible for each user . Each team will have user access to the server, separated by groups of users, with access privileges defined beforehand.

All of those users will constitute part of the pool of resources that will now be created as a new project file containing a list of the system users, as well as a set of all the other resources to be used in the project. The list should include the E-mail addresses of each resource so that the electronic mail server directs the messages, thus installed in that same server. With the pool defined, every project file of every module is linked to the pool of resources, creating a network.

The greatest benefit of this structure is the centralized management of the team and the better visualization of the effort and the availability of each resource of the pool, independently of which module it actually belongs to. With the links established, it becomes necessary to allocate the resources in the project activities, allowing all of the responsibilities within each module to be established (Exhibit 4).

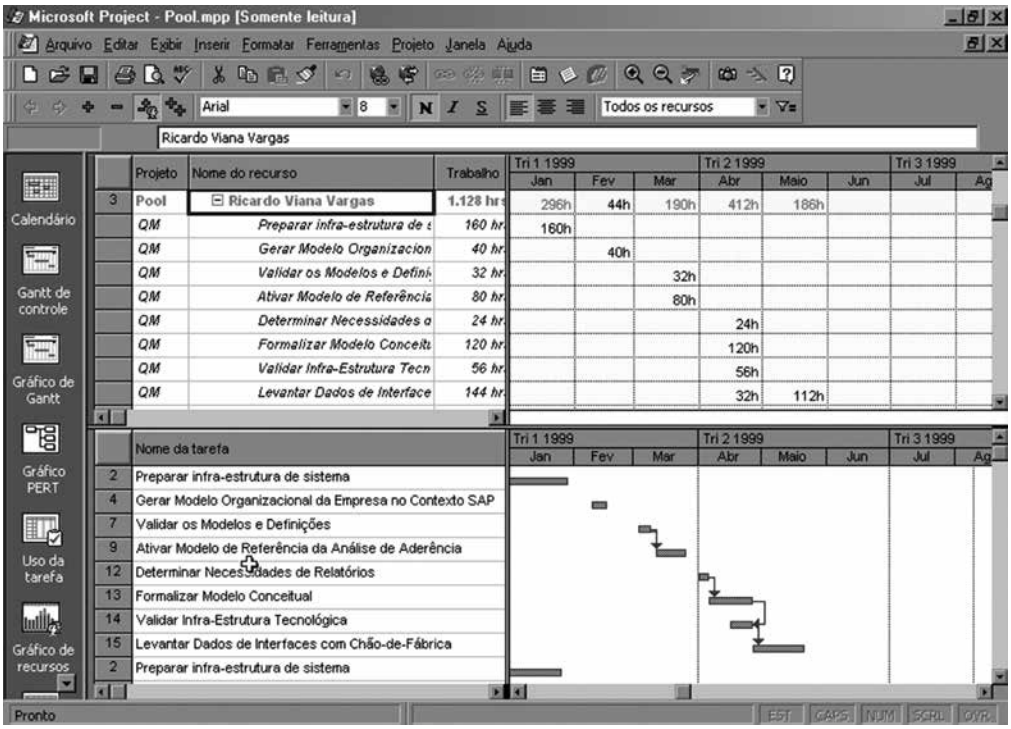
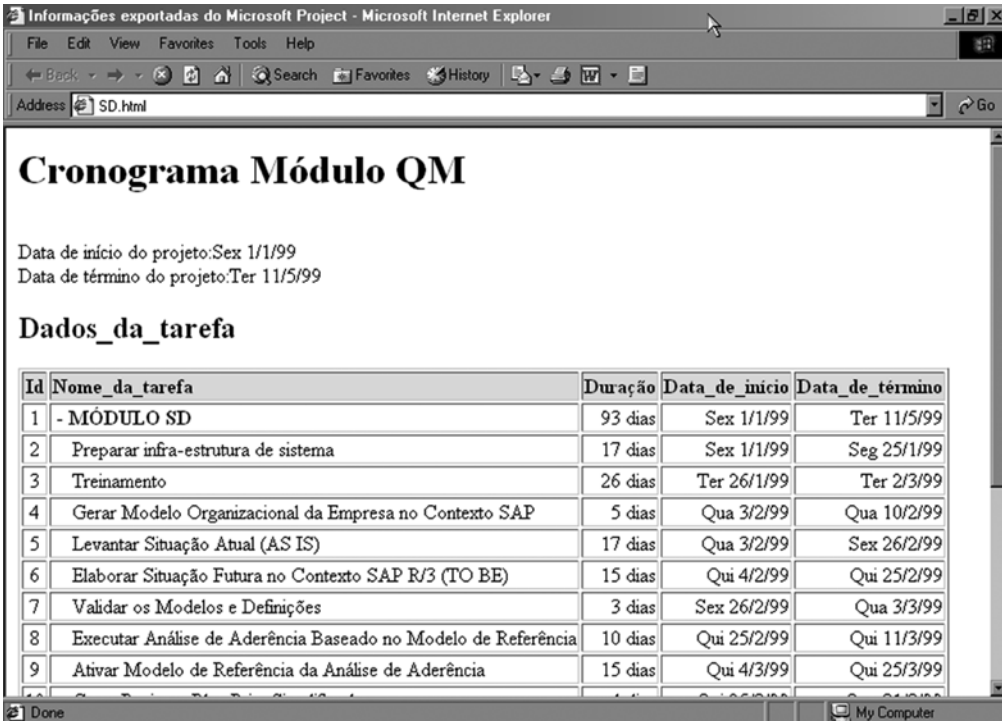


Exhibit 4 – Integrated Resource Pool control.

Definition of the Web Environment

The web environment is created through a web server to be installed in the server. All information about the project can be published as a web page using predefined Web Pages (Exhibit 5).



Id	Nome_da_tarefa	Duração	Data_de_início	Data_de_término
1	- MÓDULO SD	93 dias	Sex 1/1/99	Ter 11/5/99
2	Preparar infra-estrutura de sistema	17 dias	Sex 1/1/99	Seg 25/1/99
3	Treinamento	26 dias	Ter 26/1/99	Ter 2/3/99
4	Gerar Modelo Organizacional da Empresa no Contexto SAP	5 dias	Qua 3/2/99	Qua 10/2/99
5	Levantar Situação Atual (AS IS)	17 dias	Qua 3/2/99	Sex 26/2/99
6	Elaborar Situação Futura no Contexto SAP R/3 (TO BE)	15 dias	Qui 4/2/99	Qui 25/2/99
7	Validar os Modelos e Definições	3 dias	Sex 26/2/99	Qua 3/3/99
8	Executar Análise de Aderência Baseado no Modelo de Referência	10 dias	Qui 25/2/99	Qui 11/3/99
9	Ativar Modelo de Referência da Análise de Aderência	15 dias	Qui 4/3/99	Qui 25/3/99

Exhibit 5 – Web page with general information about a functional group in SAP/R3.

Through mail box programs for the web, which are included in most project management software, such as Team Inbox of MS Project 98, they are installed in the computers of production members of the project so that these can update their activities without having to directly access the project management software, saving the need to acquire software user licenses and making it much easier to update the team (Exhibit 6)

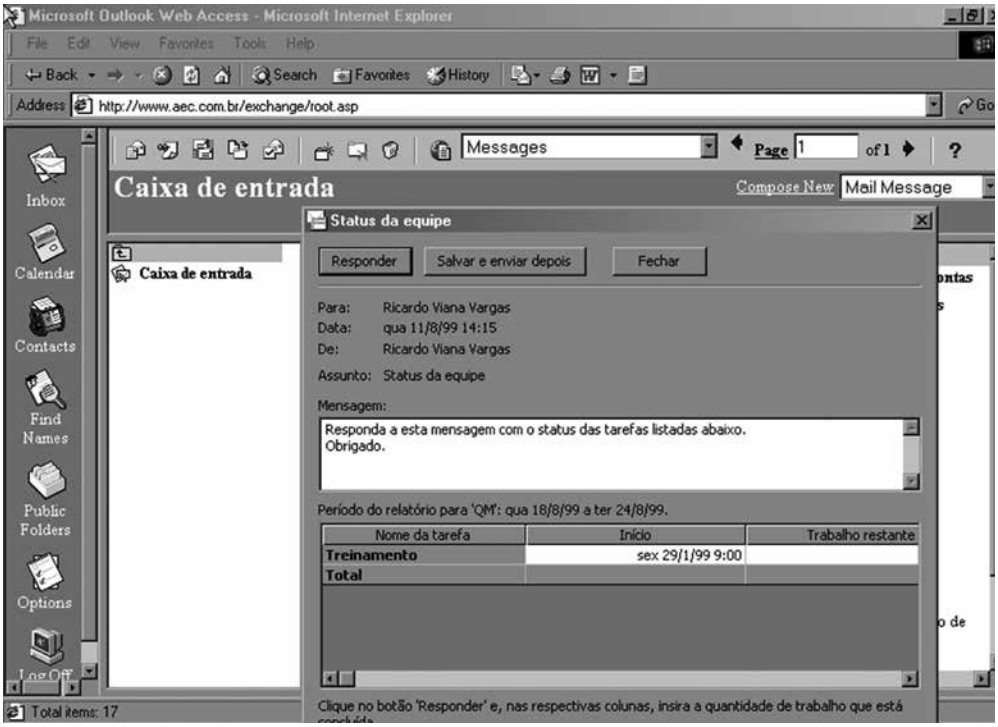


Exhibit 6 – Microsoft Team Inbox for Project Control by e-mail in a Web Environment

These results suggest an apparent gain according to the scores obtained by these participants, although the study must be deepened with other groups and other companies to produce a working result that is more scientifically proven.

Consolidating the Global Project and Integrated Management

Finally the project files of each module are consolidated, filtered, and classified, forming a global file of the project that incorporates and compares the modules item by item, allowing the total control of the project, at the detail level desired and to the extent necessary, with a simple mouse command (Exhibit 7 and 8).

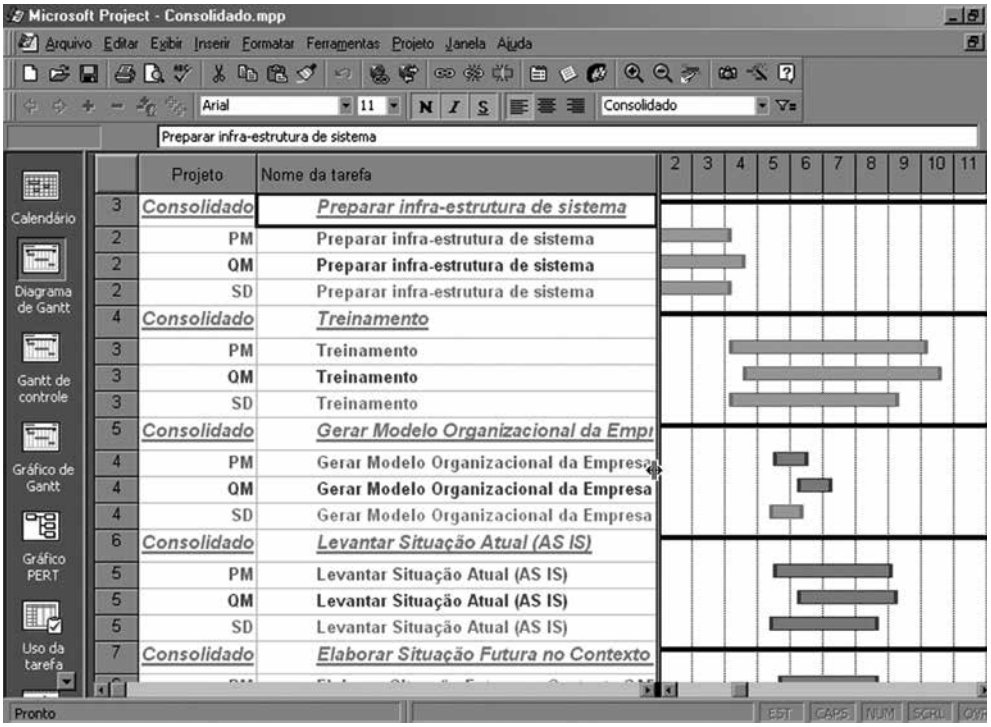


Exhibit 7 – Global Project View

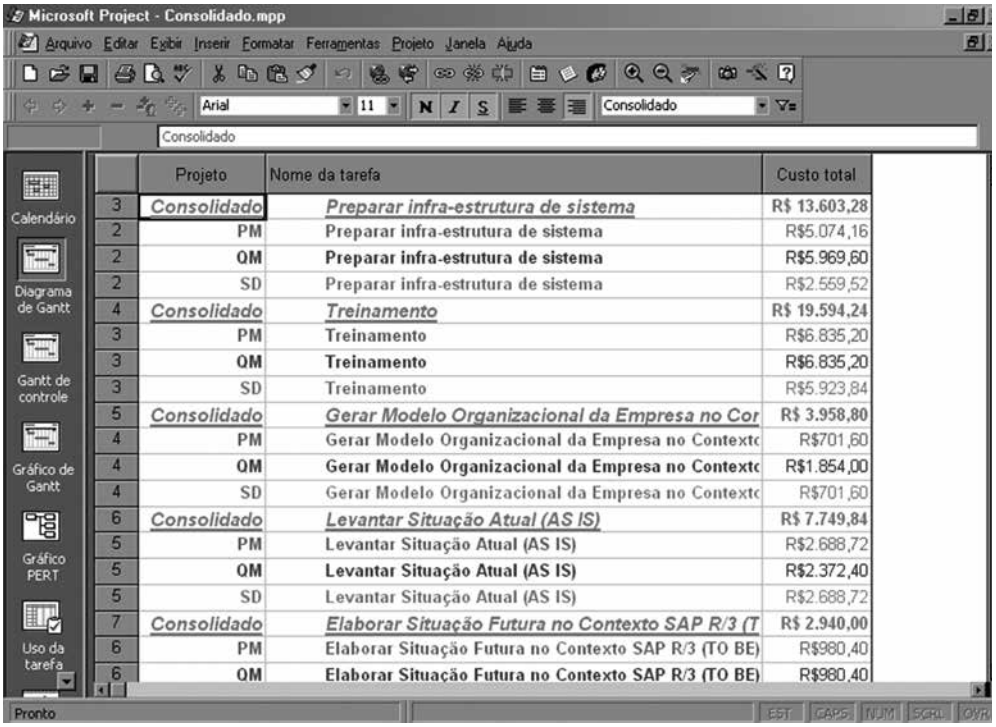


Exhibit 8 – Integrated Cost in Global Project

Conclusions

The greatest objective of this study was to find an inexpensive, simple, and viable way that can be employed to set up complex and large scale ERP systems, without causing any loss of reliability in regard to how it functions and the failures of the programs.

More Content

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