SAFE: a method to understand, reduce, and accept project risk

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Abstract

This work describes the basic elements of a risk management method supplementing a number of different public domain approaches, such as PRM body of knowledge from Project Management Institute, CTC from the Software Engineering Institute, the Euromethod strategy model, those described by McFarlan, Archibald, and others. Although the SAFE method originated in the field of information and communication technology, it may easily be extended to other domains of application. It encourages the Project Manager to gain as complete an awareness as possible of the individual, meaningful causes of risk for a specific project, by examining general and particular checklists, and by using creative group techniques and interaction. The risk definition phase is followed by a phase to plan and carry out intervention aimed at reducing the likelihood that damaging events will occur, or the extent of the expected damage. In any case, the point of arrival is the awareness that each profitable enterprise comes with a certain level of risk, and that managers are increasingly approaching entrepreneurism - that is, the ability to consciously and willingly assume risks that cannot be eliminated.

1. Introduction

Managing a project's risk means becoming actively involved in its success. A project by its very nature is complex, temporary, innovative, interdisciplinary, unusual, and at times unique. This is why it is exposed to risks that are much greater than those of an organization's running, repetitive activities. To manage risk, we must first be able to grasp and predict risk events and their interactions which, when they occur, may keep the project's objectives from being achieved. It is then necessary to design and put into practice a safety plan, that enables us to intervene as appropriately as possible with actions to prevent, monitor, and combat the individual risk elements. Lastly, we need to evaluate, both a priori and in the field, the effectiveness of the action plan adopted, in order to make the appropriate modifications to the risk management system. All this costs time, effort, and money, but it is the only road to take if we wish to minimize the losses expected for each specific project effort. In fact, reacting to unexpected events as they occur is most certainly a way of proceeding that offers immediate, but unfortunately only apparent savings. In fact, experience tells us that emergency management always involves spending more energy than managing ordinary activities. Therefore, we need to adopt methodical approaches to the work that are flexible and suitable for treating all types of projects, because we cannot spend more for managing risk than we would lose by not managing it. Therefore, the ideal approach is one that adapts itself to the importance of the project: small management investment for small projects, and a large management investment for large projects.

This document describes the SAFE (**S**afe **A**ctivities **F**or **E**nhancement) method, which is the result of supplementing various conceptual and practical approaches to the issue of project risk management, including PRM body of knowledge from the Project Management Institute, CTC from the Software Engineering Institute, the Euromethod strategy model, as well as the techniques proposed by McFarlan and Archibald. The method allows the Project Manager to gain the most complete awareness possible of the individual and meaningful causes of risk for a specific project by examining general and particular checklists, and by using creative group techniques and interaction.

This work starts by clearly defining such terms as problem, objective, and risk: concepts that are often assumed as primitive, which is to say in need of no deeper analysis, but that in truth are frequently misconstrued. Their explanation suggests ways to better understand the risk associated with specific situations, and to be able to face these risks with better hopes for success. Risk management is then presented and described as a repetitive organizational process to be performed at special times and whenever necessary, within the project's life cycle. Lastly, this is followed by a description of the various activities provided for, indicating the inputs, outputs, techniques, working tools, and suggested skills.

2. Problem, Objective, and Risk

Why is a project born? Beyond the specific motivations for each individual initiative, a more general set of responses may be glimpsed, as follows:

- to solve an existing problem
- to avoid a future problem
- to create new opportunities

The word "problem" is used in two out of these three reasons, and a project may, in effect, be likened to a highly organized and structured "problem solving" process. We need to better analyze the meaning of this concept which is highly used, and therefore often deemed primitive, which is to say intuitive and not subject to further specification.

When we think about it, a problem may be imagined as *an unwanted state of affairs* (and one, therefore, to be removed or solved). It may regard the present or the future, indifferently. Why do we say state of affairs? Because it may be a configuration of a set of variables of every kind (economic, organizational, productive, social, legislative, and so on). And why unwanted? Because if we wanted it, it would not be a problem! That is, we would have no interest in determining the causes of a given situation to try to remove them or cancel their effects that are considered negative or undesired.

Therefore, the starting point for each project should be that of thinking about the circumstances considered negative by the interested parties, and about their direct or indirect causes, before considering how to solve these situations.

How are we to analyze a problem to be able to come up with the most suitable solution? We must:

1. seek to establish the boundaries of the context we will be working in (the boundaries of the problem area)
2. identify the interested parties
3. describe the various aspects of the problem (and sub-problems)
4. identify the links between the sub-problems
5. make a cause and effect grid (problem network structure).

In fact, it appears obvious that without an appropriate definition of the *true* causes of a problem situation, we cannot even begin to implement a solution, unless we are very lucky. There is abundant literature providing a deeper look at problem setting and problem solving techniques. Here we would like to stress that a very common error in treating problems is that of spending little energy to define the problem - as an unwanted state of affairs accompanied by its cause and effect grid - and of turning to quickly to identifying actions to be performed. In this way, we risk representing the problem as *"the lack of the first solution that comes into our minds."* Therefore, we often behave as is we had ready-made solutions in search of problems. It is perhaps not worth pointing out that in this case, the true problem sooner or later crops up again, even more urgent and pernicious than before. When, for example, a company is not doing well economically, the first action that comes to mind is to reduce costs, so we think that the problem is that costs are too high. However, at times the circumstance considered negative by shareholders does not regard costs alone, but the operating margins (revenue-costs) that are too low, and a possible solution to this problem may therefore be that of increasing revenue in addition to reducing costs.

If a project is basically linked to solving a problem, how may we define its "success?" Certainly, few would hesitate to say that success lies in achieving the set objectives. But what, then, is an objective? This is also an idea often supposed to be primitive, but that is never analyzed in a more careful and in-depth manner. And when we think of it, we end up describing a concept complementary to that of a problem: an objective may be defined as *a wanted and intended state of affairs*. "State" for the reasons already explained; "wanted" because if it were not, we would not establish such a costly and demanding apparatus to achieve it; and lastly, "intended" because not only would we like to achieve it, but we wish to achieve it and therefore we work to achieve it. An objective is what we wish to achieve in one way or another; it may be expressed in terms of *result* and generally (not always) is *what remains* when the project is completed. Examples of objectives may be:

- improving efficiency in the sales process by 30% in one year;
- radio coverage of a provincial area by the end of the quarter, and at a cost of no more than *x*;
- reducing the public's wait times by 20% during the first three months of the business year.

The objectives – as *results* - should be described more in terms of *being or having* rather than *doing*. The most common error in this regard is that of considering actions needed to produce results as objectives. When we implement a market research, the project's objective is to acquire knowledge as to the expectations or behaviour of a customer segment, and not to "do" the survey, that is, to perform the activities of defining, gathering, and analyzing the interviews. Therefore, what often occurs in actual projects is that we confuse the means with the ends - instruments with results - or at least we leave the link between them implicit. Often, there are no clear organizational authorities connected to the results to be achieved, because knowledge of the "ends" is kept on the *upper floors* of the organization, while only development of the instruments is delegated. The problem is that then there is no one responsible for pursuing consistency between the instruments and the ends on a higher level. The risk is run of creating optimal technical means that, however, no one uses and that do not produce the organizational results implicitly desired by management.

If an objective is a wanted and intended state of affairs, we may wonder *by whom* it is wanted and intended. In effect, we know that the project's objectives are set by myriad subjects, sometimes working against one another. Therefore, an objective is almost always linked to range of acceptability of its values, which is the result of negotiating. For example, if the budget agreed upon is Lit. 100 million, spending 110 or 90 million may still fall within the margin of tolerance accepted by everyone. If we now suppose charting each objective on a different Cartesian axis of measurement, the success zone may be defined as the solid with n dimensions, characterized by all the ranges of tolerance existing for the important project variables (time, cost, quality, resources, etc.). A project's success lies therefore in being able to have its actual results fall within this volume. Figure 1 represents a simplification of the concept on a space drawn in three dimensions.

The *"project stakeholders"* are those that are qualified to express interest in the results or in the project's working process. These are generally:

- project customers,
- result recipients,
- participants in development,
- external regulators.

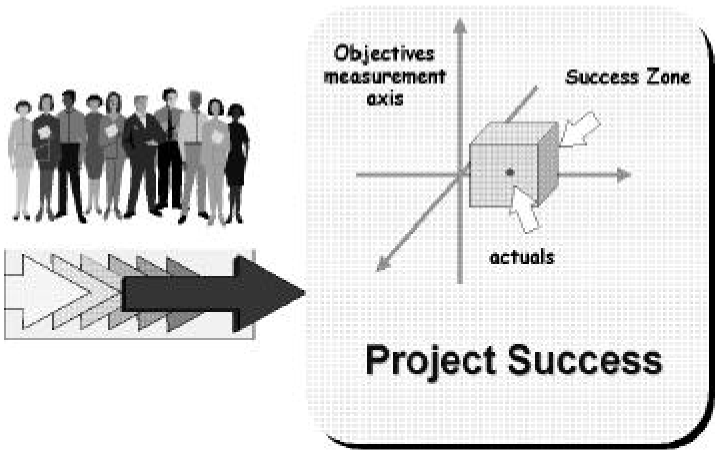

Figure 1

In addition to these human suppliers of *requirements* are the inanimate factors expressing constraints and conditions on the project. Examples of these inanimate factors include the need to design a system in a manner compatible with other existing or future systems, complying with ISO 9000 regulations, etc. These implicit technical requirements may be explicitly assumed by any animate subject (normally the Project Manager) in order to be suitably treated by the project.

Given this, it is clear how a project's risk may be defined as the ***likelihood of not succeeding in achieving one or more of the objectives specified and agreed upon for it***.

Therefore, the main risk is the possibility that the various pieces of the objectives puzzle will not fit together: this would represent the project's general failure. As mentioned above, this is a risk that is run whenever we wish to negotiate the various characteristic aspects (functional requirements, duration, costs, skills, personnel, etc.) separately, at different tables, and with different subjects. In fact, it is possible for agreement to be reached on the various partial objectives, but for these to be incompatible with one another. In other words, from the very outset, the *success zone* for the project in question does not coincide with *a feasibility zone*.

The causes for riskiness may be internal (endogenous) or external (exogenous). We may consider the endogenous causes for risk as basically linked to the proper function of the project group (able, motivated, united, etc.) and the soundness of the technical and organizational solutions decided upon, as well as the ability to effectively and efficiently manage the available resources. As regards the external causes, we may observe that each project is born, develops its existence, and comes to an end in relation to a particular environmental context. To compare the project to an open biological system that exchanges information and resources with other existing systems, the success of this organisms is highly dependent on its ability to positively relate to the surrounding environment by which it surely tends to be conditioned. The customers for a project, its recipients, the external regulators, suppliers, and competitors, are all examples of players populating the project environment, while the objectives, financial resources, technologies, and logistics are all examples of elements for which an exchange is made between inside and outside the "system." To the project, the environment represents opportunity, but also threats to its survival, In fact, there are myriad elements that may cause problems that at times have dramatic repercussions on the project's very survival.

We have written of problems and risks: but what difference is there between these two concepts? A problem may be described as an unwanted state of affairs that may regard the present or future, while a risk, as an initial approximation, may be thought of as the likelihood that a problem may manifest itself. In non-rigid but suggestive terms, a risk may be thought of as *a problem that has not yet occurred, but that may do so*.

The concept of probability is intrinsic and essential to the concept of risk. Therefore, to analyze risk effectively, we need to analyze the weak signals that originate from inside the project or from the surrounding environment, and that may be early indicators of the occurrence of the associated problem. A common proverb among truck drivers in many nations has it that behind every rolling ball is a running child! The right time to put on the brakes is when we see the ball, and not when we see the kid chasing after it! Often, when the risk signal becomes strong and easily visible, it is too late to prevent the associated problem from occurring.

However, in a real project, in addition to evaluating what things could go wrong and with what probability, we need to differentiate important things from marginal ones. This is why the probability component on its own is no longer enough to define risk. We need to introduce the concept of *"expected statistical value."* In other words, we may assert that risk is a ***quantity proportional to the value of the damage caused by a given problem, multiplied by its probability of happening***. This allows us to focus our managerial energies on controlling things that are truly important to the project, and not merely the annoyances.

3. Risk management as an organizational process

As already pointed out, managing risk is an activity that cannot be left to improvisation. It is therefore necessary to define the standard working procedures or processes that help those involved in setting up, leading, and evaluating a particular project. These processes should help employees identify, quantify, prevent, monitor, and combat risk events. It may be worth stressing that the advantages of a standard evaluation method include that of enabling different organizational subjects to communicate and share the perception of a project's riskiness. In this way, to the statement "this project has a high degree of risk," we can avoid hearing ourselves respond: "… because you are not able to do it!"

Unfortunately, in current practice, risk evaluation is an activity that either is not performed explicitly, or is performed only at the beginning of the project. Risks, however, change as time goes by, in their nature, their probability of occurring, and the amount of damage that they may cause. Therefore, we always need to maintain a keen interest in this aspect, repeating the appropriate process a number of times. Risk management activities must take place at particular moments in the project's life cycle (feasibility study, examination of the functional specifications, partial releases), and whenever deemed necessary given the varying project conditions, or in light of different knowledge gained of these conditions over time.

Like any process, risk management may be expressed as a set of activities, each characterized by specific input and output elements, and by techniques, tools, and appropriate skills. The following chapters will use the aforementioned scheme and will provide an extended description of some important aspects.

4. The SAFE method: general structure

As figure 2 illustrates, the first risk management activity is **Identifying the Risk** (Risk Activity no. 1 – **RA1**), in which all the major sources of risk are identified, listed, and entered into the **Risk Management Database** (**RMD**) containing all the information of importance for applying this method. This is followed by **Quantifying the Risk** (**RA2**), which makes it possible to obtain as objective a view as possible of the instinctive perceptions of the project's riskiness. After these two activities, a report may be drafted on the nature and degree of risk to which the project is exposed (**Risk Assessment Report - RAR**).

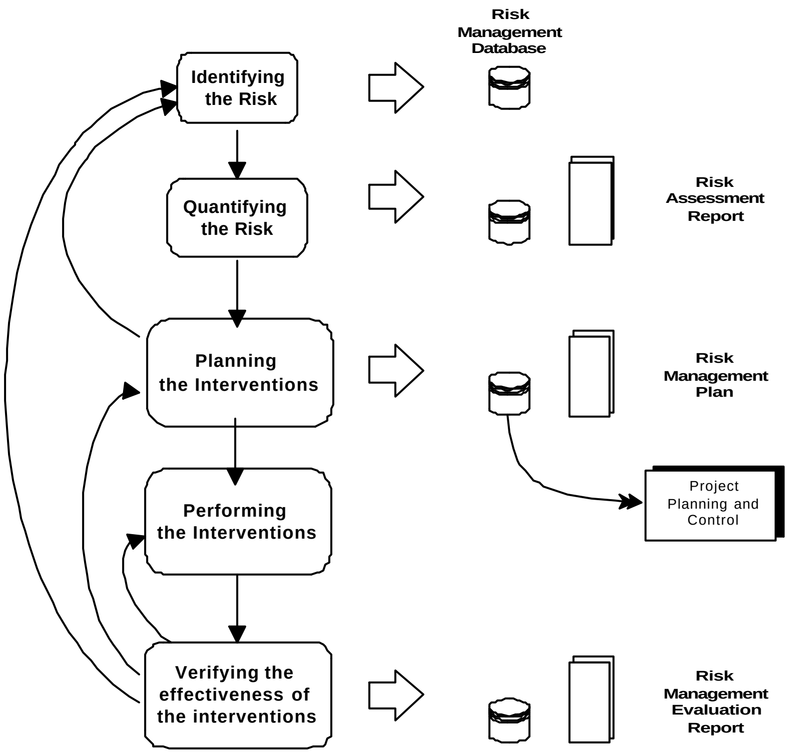

Figure 2

After the diagnosis phase (RA1+RA2), the next step is to identify general and particular strategies to reduce the risk factors, both in their probability of occurring and in their possible effects. This is done by **Planning the Interventions** (**RA3**), which makes it possible to formulate a **Risk Management Plan** (**RMP**) containing both the general indications for properly setting up the project, as well as a section identifying, a set of actions to prevent, monitor, and combat each risk factor. The purpose of the RMP is to reduce the **Unconditioned Risk** associated with the project to a **Residual Risk** that has a level of acceptability explicitly defined and documented in the Risk Assessment Report. This report is enriched by a second section regarding the estimated risk, after the RMP is applied. At this point, by comparing the Unconditioned Risk and the Residual Risk, it will be possible to assign the RMP level of estimated effectiveness in removing the risk, measured using an appropriate index. The RMP will provide precious input for defining the project's general working plan with which it must obviously be co-ordinated, as the risk management activities are project activities on their own, and as such are to be managed within the framework of integrating planning and control.

Management intervention planning will be followed by the activity of **Performing the Interventions** (**RA4**), putting into practice all the prevention initiatives provided for by the RMP, activating all the "sensors" designed for the early detection of the occurrence of a risk event, and lastly adopting all the countermeasures needed to combat the risks, that may have been transformed into problems to be neutralized, or at least mitigated.

The proposed method's final activity is that of **Verifying the Effectiveness of the Interventions** (**RA5**) put into effect. This is needed in order to confirm or dispute the validity of the RMP, in order to plan new prevention, monitoring, or combating interventions more effective than those adopted to that point. The results of this activity take concrete shape in a document called the **Risk Management Evaluation Report** (**RMER**), containing evaluations of those events that have occurred, the effectiveness of the prevention performed, and the reactions adopted. This phase may once again trigger the diagnosis phase (RA1 and RA2) and/or the planning phase (RA3).

The SAFE method illustrated here uses such tools as the cognitive map of the territory, force field analysis, the cause/effect grid, the context diagram and risk matrix, the Delphi or Shang method, the self-determination index, the index of effectiveness in removing risk, weighted analysis techniques, and more.

5. Identifying the Risk (RA1)

This activity has the objective of bringing to the explicit attention of those involved in the project, as complete as possible a set of critical elements constituting the basis for general risk evaluation and for preparing appropriate management responses.

Table 1

<table>
<tr><th>5.1. Inputs</th><th>5.2. Techniques and Tools</th><th>5.3. Outputs</th></tr>
<tr><td>• Project information:
  • Describing the problem
  • Describing the context
  • Project objectives
  • Project requirements
  • Constraints and conditions
  • Subjects involved
  • Describing the solution
  • Resources assigned
  • General working plan
• Historical information
• (Risk Management Database)</td><td>• CTC Approach
• Grid analysis
  • cause/effect
  • effect/cause
• Cognitive map of the territory
• Context diagram
• Checklist
• Interviews
• Brainstorming</td><td>• Risk Management Database
• Risk Assessment Report</td></tr>
<tr><th colspan="3">5.4. Necessary Skills</th></tr>
<tr><td colspan="3">• Creativity
• Analytical skills
• Descriptive skills
• Interpersonal communication skills
• Experience in the application domain
• Knowledge of specific techniques</td></tr>
</table>

5.5. General description

As mentioned earlier, this activity should first be performed during the project's feasibility study, and then whenever risk conditions change in nature or size.

Certainly, good management practice dictates anticipating what may be the factors crucial to the project's success or failure, at a time significant resources have yet to be invested, or irrevocable decisions made. In fact, unexpected, critical events almost always involve significant spending of resources, and at times the situation becomes irreparable.

A project's overall risk is determined by the individual elements of risk - independent of or related to one another - each with its own likelihood of occurring, and its own impact on the final result, which would take place if left to act with no control. The precise composition of partial likelihoods for obtaining the general risk is the domain of Probability Calculation. Given a simplified situation in which the various critical elements are independent of one another, we may suppose that the probability of a total failure is the sum of the probabilities of the partial elements.

In identifying these basic elements, we need to avoid the scholastic temptation to list the myriad, normal circumstances on which proper performance of the work depends, and to focus only on the Critical Factors most responsible for success or failure, in accordance with the well known law of Pareto (20% of the factors, 80% of the results).

To descriptively formulate each individual critical element, an approach called CTC [1] - Condition-Transition-Consequence - may be adopted. The condition specifies a situation whose occurrence may, through a Transition that can be associated with a degree of probability of occurrence, lead to an undesired Consequence. In an approach of this kind, an element of risk may be formulated as follows: if situation A occurs, then the probability is x% that undesired situation B will follow. For example: "if the group's technical skill in the technology to be used is low, then there is a high probability that the result will be unreliable and unsound." If we find a way to assign probability values to conditions and transactions, as well as scores to the consequences' impact, we will be able to evaluate the project's risk.

In identifying the individual critical elements, we may look *forward* (*"forward chaining"*) - starting by listing the situations that may occur with a certain possibility, and then seeking the possible damage caused to the project by these situations - or *backward* (*"backward chaining"*) - starting from the undesired consequences, and then seeking the situations that may generate them.

In both cases, such instruments may be used as the cognitive map of the territory, the context diagram, and the checklist to classify the critical elements of the projects.

5.5.1. Cognitive map of the territory

This is a sociogram that graphically and textually represents the project's various "project stakeholders" with their characterizing relationships. The lines of connection may be diversified based on their known or presumed critical nature. The sociogram offers the following advantages:

- there is no risk of neglecting subjects qualified for consideration "in the project"
- analysis of the inter-dependencies makes it possible to highlight the so-called "dangerous relationships" that generate risk for the project
- the cognitive map can help apply force field analysis regarding the project's objectives (forces in favour – forces against)

5.5.2. Context diagram

The context diagram *(Fig. 3)* is a circle-shaped graphic tool that stimulates the search for critical elements that may affect the project especially, but not exclusively, in its relationship with the external context - that is, the environment in which the project must live as harmoniously as possible. It is described in [2], but is used here in a considerably different manner. The graph is divided into areas representing the intersection of two different ways of sectioning the circle - slices and concentric circles. Within the various areas, the critical elements are placed, and may be of two types: factors and subjects.

Factors are inanimate entities with no decision-making or action-taking powers. They may be events, circumstances, conditions, objects, configurations, information, and so on. They are marked by the fact that they can cause problems or damage (but also advantages if well managed) for the project. Examples of factors include the existence of regulations, the availability of money, and consumers' propensity to make purchases with credit cards.

Subjects on the other hand are entities with powers to commit or omit actions important to the project's success. Subjects may be people, organizational units, or even information processing systems. Examples of subjects include privacy authorities, the managing director, competitors, end users, consultants, and expert systems.

The slices of the context diagram represent the classes in which the various critical elements may be sought. These are, for example, society, politics, laws/regulations, the economy, technology, logistics, geography, strategies, organization, and skills. The list is not comprehensive and new reference classes may be defined and used. These classes, then, must not be experienced as an obstacle to using the instrument, but as an advantage. They are used only to stimulate the imagination to seek possible critical elements using a verification list. However, once a certain element becomes known, it is useless to spend more time than needed to seek to place it in the right slice. In fact, there are many elements that may straddle one or more classes. What is important is being able to pull them out of oblivion, and not where they are placed in the chart. The following are examples of elements (factors and subjects) regarding the various classes:

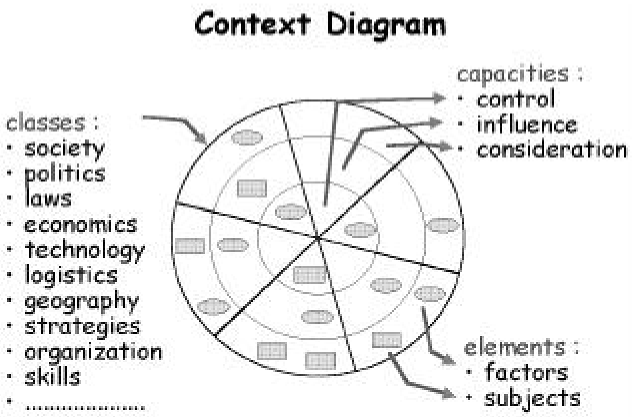

Figure 3

- **society**: schooling of a geographical area, vandalism of the territory in question, the population’s ecological awareness, the director of a school, customers.
- **politics**: the mayor of a municipality, environmental corruption, relations with the mayor, the federalist orientation.
- **laws/regulations**: antitrust regulations, safety legislation, privacy legislation, ISO 9000 standards, the European Parliament.
- **economics**: a territory’s average per capita income, project budget, an expert system automatically issuing purchasing orders.
- **technology**: programming language to be used, machine tools available, a city’s cabling, a machine’s response capacity, the hardware supplier.
- **logistics**: transport infrastructures, rooms to work in, the cabling of a building, the accessibility of a plot of land, technical support services.
- **geography**: mountains present in the territory, the seismicity of the area, precipitation level.
- **strategies**: of the business, competition, the government, the European Community, and the ombudsman for publishing.
- **organization**: relations with the user, available resources, procedures to be followed.
- **skills**: technical, managerial, relationship, and communication skills.

It is important to be able to assign each identified critical element a degree of controllability deriving from the so-called **project capacities**. This is the third element in the context diagram: the concentric circles.

There are three possibilities, although here as well, there are many shades of grey between black to white:

- **Control**: the project has complete mastery over the element, and is able to determine its behaviour directly, with no intermediaries. In this case, it is said that the project (understood as the Project Manager and those people considered members of the working team) may intervene on the factor or subject, preventing the corresponding problem from occurring or reducing it to harmlessness. We repeat: in this case, it is possible to successfully intervene on this critical element by modifying it. An example of a controllable factor may be skill in a given technology: if it is not there, or is removed, it may be acquired either by recruiting suitable personnel or through specific training.
- **Consideration**: the project exercises no control over the element, but is conditioned by it. In this case, the project is powerless to express actions that make it possible to modify the factor or the subject in question, and we cannot oppose the occurrence of the corresponding problem. However, this does not mean that we cannot cancel out the negative effects of the problem, but only that we cannot act on the element, and that we are therefore forced to act on the project itself. If it is impossible to adapt the environment to our own needs, we will adapt our abilities to the environment. So this is the choice of selecting strategies highly adaptable to, rather than aimed at transforming the context. An example of an element to be considered is an earthquake: nothing can be done to prevent its occurrence, but precautions can be taken and emergency plans implemented to cancel the risk of the project's failure following an earthquake.
- **Influence**: the project may exercise only indirect influence on the element, and with uncertain results. We are not sure we are able to modify the factor or influence the subject: that is, we are estimating a 50% probability of success and a 50% probability of failure. Once again, this does not mean we cannot do anything: we can choose a behaviour strategy that is half adaptive and half transformation-oriented. This situation lies halfway between the two extremes presented above. An example of an element of the area of influence may be the project budget: we may find ourselves in a situation of requiring, and managing to obtain, its review through intervention by top management, appropriately sensitized by us.

We may be led to believe that the project risk is proportional to how many elements out of the total are in the area of consideration, but this is not the case. In fact, assigning a critical element to one capacity or another neither increases nor diminishes its probability of occurring, nor the damage it may cause - that is, its degree of riskiness. Total risk, on the other hand, shall in some way be proportional to the set of identified elements, regardless of where they are placed by area of influence.

5.5.3. Using checklists

There are two references of importance for preparing checklists useful for identifying the elementary project risks. The first consists of the taxonomic risk tables published by the Software Engineering Institute [3], and the second is the Euromethod strategy model [4], a method developed on the European level to successfully manage customer-supplier relations in the software field. See the bibliography for a closer look at these approaches.

6. Quantifying the risk (RA2)

This activity has the objective of providing as measurable as possible a basis for evaluating the general project risk.

Table 2

6.1. Inputs	6.2. Techniques and Tools	6.3. Outputs

• Project information
  ◦ Describing the problem
  ◦ Describing the context
  ◦ Project objectives
  ◦ Project requirements
  ◦ Constraints and conditions
  ◦ Subjects involved
  ◦ Describing the solution
  ◦ Resources assigned
  ◦ General working plan
• Risk tolerance accepted by *project stakeholders*
• Historical information
• Risk Management Database
• Risk Assessment Report
• (Risk Management Plan)
	• Risk matrix
	• Probability calculation
	• Delphi / Shang method
	• Empirical/heuristic rules
	• Simulation techniques
	• Cost estimation techniques
	• Economic analysis techniques
	• Work meetings
		• Self-determination Index
		• Unconditioned Risk
		• Residual Risk
		• Risk Management Plan Effectiveness Index
		• Risk Assessment Report
		• Risk Management Database

6.4. Necessary skills		
• Forecasting skills • Analytical skills • Communication skills • Descriptive skills • Experience in the application domain • Knowledge of specific techniques		

6.5. General description

As we are dealing with risk from a quantitative standpoint, it must be pointed out that its assessment is not absolute, but depends on two basic factors: time, and the countermeasures adopted. The former is linked to the fact that with the passage of time, risk elements tend to change in terms of likelihood of occurrence and the damage that may be caused to the project. For the second aspect, it must be observed that the amount of the risk also depends greatly on the strategies implemented to control it. It is therefore possible to make an analysis of the critical elements before and after adopting a specific action plan to reduce risk (result of RA3). We may then expect that the initial evaluation is significantly higher than the subsequent one, by virtue of the effectiveness of the identified action plan. The first may be called “Unconditioned Risk,” because it is linked to the impact a number of elements would have if they were left free to act unopposed. The second may be called “Residual Risk”.

The Risk Matrix *(Fig. 4)* is the linear transposition of the circular context diagram discussed above. The elements (factors and subjects) are rendered as rows, and the capacities as columns. Classes, on the other hand, may be represented by groups of rows (all, and only, those corresponding to a given class's elements). At the intersections between a class's element and the corresponding capacity of reference, we may write in a score. Of course, each row will have only one intersection that will be assigned a number value, since an element cannot belong to more than one capacity (Control, Influence, or Consideration) at the same time. This grade will express judgement as to the <u>*expected value of the damage*</u> (probability of occurrence multiplied by the size of the consequent damage) that the critical element may cause to the project if left free to act unoppposed. In essence, we are rating the danger of a particular element with respect to the project's success.

Risk Matrix

Critical Element	Control	Influence	Consideration
E1	a		
E2	b		
E3		c	
E4			d
E5	e		
E6		f	
E7			g
E8			h
E9			i
E10		l	
E11		m	
E12			n
E13	o		
Totals	X	Y	Z

Figure 4

Grades may be assigned on a scale of 1 to 10, in which 1 represents the minimum impact (marginal incidence) and 10 the maximum impact (the project's complete failure). It is advisable to assign this grade after having separately estimated the likelihood of the event's occurrence (from 0 to 1) and its impact if it occurs (from 1 to 10). In making this initial evaluation (Unconditioned Risk) we must force ourselves not to consider the possible countermeasures that may be adopted to mitigate the risk, since this will be expressly the object of a second evaluation (Residual Risk).

To increase the level of objectivity of the grading, repetitive group methods may be used, such as the Delphi method or its variant Shang, which make it possible to use the so-called "expert judgement" more effectively.

Once the grade is assigned, the scores can be added by column, thereby obtaining three values: total control (X), total influence (Y), and total consideration (Z). The **Self Determination Index** may then be calculated as follows:

$$\mathbf{SDI=100*(X+Y/2)/(X+Y+Z)}$$

This is a percentage index that assumes values from 0 to 100, and that indicates the project's degree of self and external determination. An index close to 0 indicates that the project (externally determined) is unable to change in any way the critical elements that most influence the project's success, but can react to them by adaptation - that is, by expressing introverted actions aimed within the project itself. An index close to 100 indicates that the project (self determined) is able to modify all that is important to its success, and therefore will above all adopt behaviour to transform the context - that is, extroverted actions. The reason why half of value Y is added to value X derives from the fact that we have assumed a 50% success rate for our indirect capacity to act on the element. This is the same as saying that half of the points in the area of influence can be added to control, and half to consideration.

Therefore, the Self Determination Index is not a global indicator of risk because it expresses a relationship between two risk classes: endogenous risk (control area) and exogenous risk (consideration area). However, it is impossible to say which of the two is preferable. It depends on the response strategies we manage to develop from time to time.

The Self Determination Index is a highly powerful indicator of the degree of flexibility and adaptability that must be incorporated into the project for it to be able to succeed or, if we prefer, of the degree of power that the project deems necessary to have.

The value of this index suggests highly precise managerial indications capable of fostering the different types of behaviour necessary. For example, a project with a low index must adopt choices favouring flexibility, which may consist of an open contract between the parties, an easily reconfigurable team, a co-ordination committee with the users present in it, a flexible budget, top management’s support, etc.

The self determination sub-indexes can be calculated for classes of elements *(Fig. 5)* in such a way as to have a partial view of the areas of greatest self or external determination. The various indices may be represented on a polar diagram, such as the one illustrated in the figure, to have an immediate idea of the areas uncovered and those covered by control.

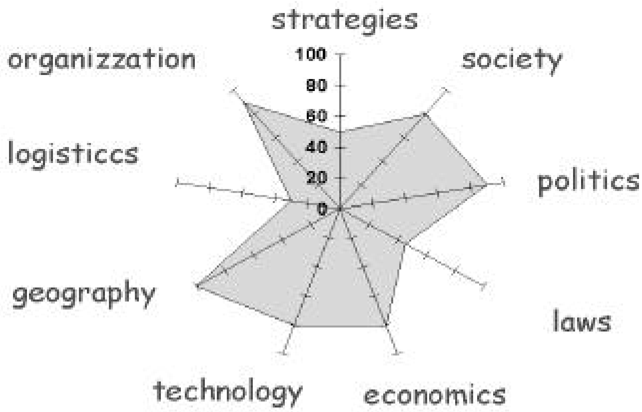

Figure 5

Turning now to determining general risk, we can state that a rigorously mathematical analysis would be inappropriate in this context, since there are too many subjective variables in play. However, we may develop some empirical rules to determine the overall risk level, starting from the individual, underlying critical elements and their grades.

Once the matrix’s grades have been expressed on a scale of 1 to 10, and recalling that 10 represents the maximum impact on the project - that is, its failure - we may consider the following empirical rules:

- total matrix grades between 1 and 50: low risk;
- total matrix grades between 51 and 100: average risk;
- total matrix grades greater than 100: high risk;
- however, the following special cases override the aforementioned rules:
- one or more grades equal to 10: certainty of failure;
- one or more grades equal to 9: very high risk;
- a single grade equal to 9 and more than 5 grades between 6 and 8: very high risk;
- no grades equal to 9, and at least 3 grades between 7 and 8: high risk;

It should be kept in mind that risk evaluation, and consequently the use of the instruments introduced, is dynamic and not static. The grades assigned to the various critical elements, like their very nature, change over time and depending on the management choices implemented - that is, on the risk reduction strategies. The context diagram, the risk matrix, and the Self Determination Index are snapshots made at a given instant, that might no longer represent the true situation at a later instant. For example, a project that upon first analysis appears externally determined may, after appropriate intervention by top management, increase its level of power and become self determined.

Of course, we would expect project risk evaluation to be influenced by implementing the RMP, and therefore we may, as mentioned earlier, speak of a risk evaluation before and after the plan is implemented.

Therefore, it may be useful or necessary to derive the context diagram, the risk matrix, the Self Determination Index, and the general risk level both before and after the RMP is defined. The relationship between the risk matrix's total grades before and after the specific action plan is prepared may be considered as a general indicator of the plan's presumed effectiveness.

Therefore, if we define the Risk Management Plan Effectiveness Index as follows:

RMPEI=100*(1-(Risk after/Risk before))

then, the greater the RMPEI, the greater our ability will be to respond to critical elements. A value of 30, for example, will mean that we have a 30% degree of effectiveness in reducing risk - which is to say that we estimate we are able to reduce the Unconditioned Risk by 30%, leaving a Residual Risk equal to 70% of the Unconditioned Risk.

A quantitative analysis like the one proposed may be accompanied by *an economic analysis in monetary terms* if we are able to estimate the possible losses caused by occurrence of the risk events, in order to be able to compare them at a later time with the risk management costs involved with implementing the corresponding management plan (RMP). The analysis may be performed using the customary cost/benefit evaluation techniques based on the expected loss values (possible loss * probability of loss).

Lastly, to support risk quantification, such simulation techniques may be used as the Montecarlo method, business games, and time and cost determination models (PERT, GERT, CPM, etc.). In this regard, the approach discussed in [5] is an interesting one.

7. Planning the interventions

This activity has the objective of planning a consistent and sustainable set of activities and responsibilities for risk management, as well as to identify the measurement procedures associated with controlling the results.

Table 3

7.1. Inputs	7.2. Techniques and Tools	7.3. Outputs

• Project information
  • Describing the problem
  • Describing the context
  • Project objectives
  • Project requirements
  • Constraints and conditions
  • Subjects involved
  • Describing the solution
  • Resources assigned
  • General working plan
• Risk Management Database
• Risk Assessment Report
• (Risk Management Plan)
	• Checklist
	• Empirical/heuristic rules
	• Estimation techniques
	• Economic analysis techniques
	• Decision trees
	• Weighted choice techniques
	• Planning tools
	• Responsibility matrices
	• Work meetings
		• Risk Management Plan
		• Data for general project planning
		• Economic reserves
		• Contract situations
		• Risk sensors
		• Objectively Verifiable Indicators(OVI)

7.4. Necessary skills		
• Creative skills • Communication skills • Experience in the application context • Knowledge of specific techniques		

7.5. General description

After this activity, we have a precious list of actions and of the corresponding organizational responsibilities that will make it possible to minimize the impact that the individual risk elements may have on the project's general success, by acting on both the probability of occurrence and on the amount of damage envisaged for these elements.

The Euromethod Strategy Model [4] provides indications as to the possible procedures for managing a project based on the values assigned to some risk factors, which are classified in terms of complexity and uncertainty according to the following scheme, and that refer to the project's application context and the system's impact on the organization (organizational risks) and on the automated information system (technical risks).

Risk factors that can be attributed to complexity

- Management complexity
- Project size

Risk factors that can be attributed to uncertainty

- Uncertainty of requirements
- Technological innovation

The model calls for deriving a set of indications based on the classification of the preceding elements, in terms of:

- project segmentation (single, incremental, or evolutionary solution)
- defining the points of decision to be made during the project

* modes of project control (low, medium, and high formality).

In addition to the general indications on setting up the project as stimulated by applying a model such as the preceding one, it is possible to derive from analysis of the context diagram specific actions for each critical element identified therein. The consequent actions may be of three types: prevention, monitoring, and combating. **Prevention** aims at preventing a given critical element from occurring as a problem. **Monitoring** is to find that either a given critical element is nearing the danger zone, or that it has occurred and remedies must be found. **Combating** expresses the reaction to the problem that has occurred, and aims at cancelling the negative effects of these problems. Prevention acts mainly on the risk element's probability, aiming to reduce it, while combating acts mainly on the effects of the damage, seeking to minimize or remove them. In the case of an externally determined project, actions will be aimed mainly within, while a self-determined project will look mainly to the outside.

To carefully monitor a project, it is necessary to implement a set of "sensors" suitable for the phenomena in question. These sensors may be socio-technical systems of various kinds, from the most mechanical to the most human. However, these must be associated with a set of Objectively Verifiable Indicators (OVI) [6] that will provide the measurement of the state of the risk element. To create an OVI, it is necessary to identify:

* Metrics
* Measurement tools
* Original sources of the measurements
* Collection procedures
* Data verification procedures

If the action plan is well designed, implemented, and faithfully followed, it will be a form of insurance against project accidents, which may be supplemented by real insurance policies capable of covering risks that would otherwise be unmanageable.

Of course, the RMP must be sustainable by the organization, in the sense that its cost must be positively relatable to the damage deriving from failure to use it. To do this, it will be necessary to appropriately estimate management costs and possible losses, using suitable economic and financial analysis techniques here as well.

To facilitate the process of selecting the distinct possible options for solving a critical element, weighted selection techniques may be used, assigning weights to the various quality factors and grades to the selection options.

8. Performing the interventions

This activity has the objective of putting into practice the actions that were designed to manage risk, and in particular those of prevention, monitoring, and combating. All measurements will be made as needed to assess the effectiveness and economy of the RMP.

Table 4

<table>
<tr><th>8.1. Inputs</th><th>8.2. Techniques and Tools</th><th>8.3. Outputs</th></tr>
<tr><td>• Risk Management Database
• Risk Assessment Report
• Risk Management Plan
• General project planning
• Economic reserves
• Contract situations
• Risk sensors
• Objectively Verifiable Indicators(OVI)</td><td>• Negotiation techniques
• Measurement techniques</td><td>• Specific actions
  • Prevention
  • Monitoring
  • Combating
• Contracts
• Measurements on the Objectively Verifiable Indicators(OVI)</td></tr>
<tr><th colspan="3">8.4. Necessary skills</th></tr>
<tr><td colspan="3">• Listening skills
• Management skills
• Knowledge of specific techniques</td></tr>
</table>

9. Verifying the effectiveness of the interventions

This activity has the objective of evaluating the effectiveness and efficiency shown by the RMP in the field, to confirm its validity or trigger a risk management system review phase. This activity can continue with a new diagnosis phase (RA1 and RA2) or by defining new and more effective actions (RA3). An evaluation report is to be released for management and the players involved.

Table 5

<table>
<tr><th>9.1. Inputs</th><th>9.2. Techniques and Tools</th><th>9.3. Outputs</th></tr>
<tr><td>• Risk Management Database
• Risk Assessment Report
• Risk Management Plan
• Events actually occurring
• Measurements on the Objectively Verifiable Indicators(OVI)</td><td>• Checklists</td><td>• Risk Management Evaluation Report</td></tr>
<tr><th colspan="3">9.4. Necessary skills</th></tr>
<tr><td colspan="3">• Analytical skills
• Descriptive skills
• Knowledge of specific techniques</td></tr>
</table>

10. Conclusions

Risk is a management variable important to a project's success. Therefore, it must be faced methodically, and by properly assigning human, economic, and time resources. It is neither certainly possible nor convenient to eliminate all risk factors capable of causing damage to a project. Careful technical-economic analysis may help strike the right balance between risks to be eliminated and intervention costs. Risk management procedures may fully appear among those established for producing a quality system in compliance with ISO 9000 regulations. This work has described a method called SAFE (Safe Activities For Enhancement), for the complete management of all risk-management-related aspects. Starting from this process, we can appropriately tailor our organizational procedures, which will be compatible with the Euromethod approaches and the methods developed at the Software Engineering Institute. The SAFE model has been developed over the course of two years in the context of project management consulting and training interventions, in which it has proved effective. In the future, conceptual development will continue towards extending the method, describing appropriate checklists, and ensuring compatibility with more established management techniques.

11. References

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