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by Steve Revay

Never was the saying "construction is a risky business" more true than it is today. There is, however, a marked difference between the types of risks construction people previously feared and those feared today. In the past, people equated construction risks with physical peril and relied on safety measures to limit them. Over the years, the industry did a good job in this respect and construction is not nearly as dangerous an occupation today as it was twenty or thirty years ago. At the same time, the industry, for the most part, turned a blind eye to commercial risks, as is evidenced by the large number of financial fatalities today. The lead article in this Report concentrates on economic risks. It defines them, offers methods for their quantification and suggests means to control them.

RISK MANAGEMENT IN CONSTRUCTION PROJECTS

by Dr. Pierre Menard, University of Quebec and Regula Brunies, V.P - RAL

Risk taking is one of the inherent characteristics of our free enterprise system. Moreover, it is a prerequisite for those who want to succeed within this system.

In project management, the concept of risk can be defined as the possibility of an incident more or less beyond the control of the responsible parties and which could have a more or less negative impact on the success of the project; for example, the risk of discovering changed soil conditions, or the risk of a strike, or errors in cost estimation, etc.

The risk of a project increases with the number of critical incidents, the increased probability that such incidents might occur, the gravity of the impact of these incidents and finally, the weakness of control a party exercises on these incidents. In this context, the level of risk in the extremely competitive construction industry is generally higher both for the owners as well as the contractors. Unfortunately, recent history demonstrates the frequent incapacity of the industry to manage these risks successfully: project delays, cost overruns, numerous litigations, bankruptcies (without even counting the considerable stress brought about by "unforeseen" incidents on the parties as well as their interrelationships) are often the consequences of inadequate risk management of a project. For example several owners would have perhaps refrained from fast-tracking techniques had they correctly evaluated the potential impacts on delays and costs at the outset of the project.

WHAT IS RISK MANAGEMENT?

In the construction industry, the notion of risk management has several meanings depending on the objectives of the Owner or the contractor. Among the most frequent are:

■ THE DESIRE TO RECOGNIZE THE GLOBAL RISK OF A PROJECT

This objective may be desired for various motives, such as:

- The decision to invest

The owner wants to know the risk level of a project in order to judge whether to undertake it or he wants to determine the most viable projects from a more extensive list of possible projects.

- The decision to tender

The contractor wants to know whether it would be advisable to tender for a contract, taking into account the risk it represents for his firm.

- The determination of the contingency budget

Estimating the duration and cost of a construction project is a risky undertaking. The probability of under-estimating is very high as witnessed by the numerous time and cost overruns. Smart managers want to know the probability of a forecast being met as well as the various associated uncertainties yielding possible overruns. Such knowledge allows them to take measures in the form of a realistic and appropriate contingency budget.

■ THE CHOICE OF DESIGN

The owner wants to evaluate several design options in order to minimize risks not only during the construction phase but also when the future facility is operational.

■ RISK CONTROL THROUGH APPROPRIATE MEASURES

- There are several ways to minimize the impact of undesirable incidents:

- Adoption of "preventive" measures to reduce or eliminate the probability of likely incidents: for example, the choice of one supplier over another can reduce the risk of delivery delays or default.

- Adoption of "contingency" measures to reduce the impact of undesirable incidents, should they occur. Insurance as well as contractual risk allocations among the contracting parties are common practice in this regard.

- Adoption of strict monitoring and control measures of the most risky elements of a project.

THE GENERAL PROCESS OF RISK MANAGEMENT

The general process of risk management is a systematic plan composed of the following steps:

1. IDENTIFICATION OF POTENTIALLY CRITICAL INCIDENTS

2. RISK EVALUATION
   - ❖ ESTIMATING THE PROBABILITY OF INCIDENTS
   - ❖ ESTIMATING THE IMPACT OF INCIDENTS

3. IDENTIFICATION OF MEASURES TO MINIMIZE RISKS
   - ❖ PREVENTIVE MEASURES
   - ❖ CONTINGENCY MEASURES
   - ❖ CONTROL MEASURES

4. EVALUATION OF THE COST/BENEFIT RATIO OF THESE MEASURES

5. IMPLEMENTATION OF THE SELECTED MEASURES

6. FOLLOW-UP OF THE MEASURES IMPLEMENTED

Literature on risk management in project management is generally limited to the first two or three steps of this process. This is sufficient if the needs of the owner or the contractor are limited to the assessment of the global risk of a project. However, once the decision to proceed with a project has been made, it is highly recommend that the owner or the contractor implement the process in its entirety in order to minimize their risks or to limit their possible consequences.

On the other hand, the same literature often gives the distinct impression that risk management inevitably requires complex analyses based on elaborate statistical models, and evidently, the support of accomplished experts and powerful computers which are certainly not readily available to everyone. This need not be so. One of the most beneficial approaches to risk management is when a project team gathers for a round table discussion without any other tools except their experience, knowledge and paper and pencil that indeed is within everyone's reach.

The following is a detailed description of each individual step pertaining to the process.

1. IDENTIFICATION OF THE POTENTIALLY CRITICAL INCIDENTS

The risk of a project is a consequence of uncertainty created by the possible occurrence of incidents, partially or totally beyond the owner's or the contractor's control.

An incident is considered critical when it results in undesirable consequences for the project or for one of the parties involved. The first step of the process consists of the identification of the critical incidents that are pertinent to the project one wishes to undertake. Table 1 contains a partial list of principal elements of risk prevalent on a construction project. For each risk element those critical incidents are then identified which are

ENVIRONMENT RELATED RISKS	**PROJECT RELATED RISKS**
I ECONOMICAL ENVIRONMENT 1.1 Inflation Rate 1.2 Interest Rate 1.3 Exchange Rate 1.4 Energy Costs 1.5 ...	**IV** PARTIES INVOLVED 4.1 Owner financial capacity, changes, decision making process 4.2 Contractor financial structure, technical competence, management skills 4.3 Suppliers 4.4 Sub-contractors 4.5 Users 4.6 Relationships between parties nature of contracts, history of relations, disputes ...
II SOCIAL AND POLITICAL ENVIRONMENT 2.1 Laws And Construction Regulations 2.2 Protection Of The Environment 2.3 Permits 2.4 Zoning, Expropriation 2.5 Pressure Groups 2.6 ...	**V** PROJECTCONTENT 5.1 Scope Of Project 5.2 Complexity, Innovations 5.3 Design Quality Incomplete, errors, inadequate specifications 5.4 ...
III PHYSICAL ENVIRONMENT 3.1 Fire 3.2 Floods 3.3 Wind 3.4 Earthquake 3.5 Lightning 3.6 Temperature 3.7 ...	**VI** JOB SITE 6.1 Logistics 6.2 Soil Conditions 6.3 Equipment 6.4 Materials 6.5 Labour Productivity, Strike, 6.6 Accidents 6.7 ...

TABLE 1: TYPES OF RISK ELEMENTS

prone to develop within the particular context of the project. For example, in the case of the element "subcontractors", bankruptcy is identified as an incident; strike has been identified for the element "labour".

The key to this first step's success is to generate as complete a list of critical incidents as possible. There obviously is the temptation to prematurely exclude certain incidents that appear "at first glance" negligible because of their low probability of occurrence or because of their weak expected impact. However, weeding out the list should only take place during the second step which consists of evaluating the importance of risk generated by every critical incident.

It is important to note the interdependencies that may exist between certain critical incidents: for example, an act of God such as fire or flood which could damage materials or pieces of equipment, or a strike which could provoke acts of sabotage. There could, therefore, be a chain of critical incidents which must be identified, even though later on they may be discarded, and only the ultimate incident of the chain will be retained (e.g. piece of equipment that is out of service). If several chains lead to the same critical incident, the probability of this incident occurring is increased.

2. RISK EVALUATION

Evaluating a risk involves estimating its impact on the final outcome of a project. In general, success factors to be considered are the costs and the schedule, the latter often because of its impact on the former. These factors can be relatively easily quantified. In any case, a more complete risk management must also include qualitative factors such as the technical or functional quality of a product, the quality of relations between the parties, etc. Considering the high level of uncertainty whi.ch often characterizes construction projects, the development of critical incident lists may prove to be very cumbersome. However, referring to the famous law of Pareto, one can make the hypothesis that a small number of these incidents may cause most of the impacts. This second step can therefore be used as a filter allowing the identification of the more important events, i.e. those for which mitigation measures need to be identified in the next step.

The importance of a risk depends on two variables:

- the probability that the critical incident will occur;
- the magnitude of the impact it may produce.

Thus if the probability of the incident is evaluated at 25% and the magnitude of the impact at $10,000.00 the risk linked to the incident will be $2,500.00. Unfortunately, real life is not so simple. Construction projects may be the subject of a much higher level of uncertainty than are chance games or the national lottery. In fact, in the latter case, all the variables are known or can be calculated quite precisely: the possible incidents as well as their costs and the probability that these incidents may occur (win or lose) are known. Consequently, the ultimate benefits can be estimated. However, in a construction project, the possible critical incidents are not all identifiable a priori; their probability is mostly estimated subjectively and their impact is often difficult to predict.

Does this mean that rational risk-management in the construction industry is an illusion created by mathematicians? On the contrary, the higher the uncertainty, the more its effects could prove catastrophic, and the more important it is to strive for its reduction.

The proposed approach is a solution which has proven to be effective in the past. Nevertheless, the quantitative result should always be scrutinized because it is based on data which is often not precise.

A) ESTIMATING THE PROBABILITY OF AN INCIDENT

There are different ways to express the probability of a potential critical incident, for example, **the bankruptcy of supplier XYZ.** Let us examine them in increasing order of complexity:

- a qualitative statement, for example WEAK, AVERAGE or HIGH
- a discreet value, for example 20% or 0.20
- a statistical distribution - a well-known distribution example in project management is a distribution based on three estimates, i.e. pessimistic, realistic and optimistic.

The more elaborate the statement is, the more precise the estimate will be. On the other hand, it would require more thorough research to obtain reliable data as well as a more sophisticated statistical analysis.

The above example of the bankruptcy of supplier XYZ refers to a type of incident that is straight forward because in reality there are only two possibilities: either they occur or they do not.

Other incidents are more complex to deal with, in the sense that there may be several possibilities. Let's take as an example the incident of **Supplier XYZ's incapacity to deliver the ordered product on schedule.**

This incident can be treated similarly to the bankruptcy of supplier XYZ, for example, by giving it a probability of 0.20. However, in this case, the estimate is of lesser value since the impact of a delivery delay on the project depends on the magnitude of this delay, e.g. a few days or a few months or even more (if the supplier closes his doors). Therefore, in order to arrive at a precise risk evaluation, one must "theoretically" determine the distribution of the probability of a delay as a function of time and the corresponding distribution of the impact on the entire project duration. In practice, however, most of the times it is sufficient to limit the estimate to three particularly significant possibilities, such as:

- PROBABILITY OF A DELAY OF 1 WEEK: 0.20
- PROBABILITY OF A DELAY OF 1 MONTH: 0. 1 0
- PROBABILITY OF A DELAY OF 3 MONTHS: 0.05

It is therefore sufficient to estimate the impact of these three possibilities on the project to obtain a sufficiently precise evaluation of the risk.

Several critical incidents fall into this category, such as the possibility of a strike, or encountering changed soil conditions, to name a few.

B) ESTIMATING THE IMPACTS OF AN INCIDENT

The impacts of certain critical incidents can be easily quantified with respect to the schedule or the costs of a project, such as an increase in interest rates, a delay in supplying a crucial component, broken equipment, etc. In this case, the impacts can be formulated in terms of discreet values (e.g. schedule delayed by a month) or distribution of probabilities.

In other cases, a quantitative statement may prove difficult, if not impossible, even though one is almost certain that there will be an impact, and it could be a far reaching impact. A "qualitative" statement of impacts is therefore often the only possible or valid expression, without degrading its significance.

C) EVALUATION OF THE SIGNIFICANCE OF RISK

This step is to evaluate each of the critical incidents previously analyzed and to decide which of them should be retained for the next step i.e. the identification of the appropriate preventive or mitigating measures.

If the probability of an incident and its impacts have been expressed quantitatively, one can obtain a quantitative evaluation of the potential risk in terms of a discreet value or a distribution of probability by evaluating each of the probability/impact combinations.

However, if such quantitative expression is impossible, it is up to the owner or the contractor to "subjectively" decide on the significance of risk from the point of view of previous qualitative estimates. Certain risks may be judged intolerable because of the gravity of the possible impact even if the probability of the incident is weak (usually these risks are covered by insurance). On the other hand, certain less significant risks may be retained because simple and less costly preventive measures are available to protect against them.

D) WHAT EVALUATION METHOD TO CHOOSE?

The choice of the evaluation method essentially depends on three principal factors:

- the nature critical incident
- the objective pursued by the owner or contractor
- the available resources

- The Nature of the Critical Incident

As stated earlier, certain incidents are suited to quantitative evaluation but others are not. More importantly, quantification is not always essential and it does not necessarily increase "ipso facto" the precision of the evaluation.

- The Pursued Goal

If the pursued goal is to determine the global risk of a project or the magnitude of the contingency budget required for a certain level of risk, then one is justified in using the most elaborate method, i.e. the statistical distribution of the probability of the incidents as well as their impact on schedule and costs. Consequently, the result of this approach will be a distribution of the probable cost or completion date, taking into account the risk set by each of the critical incidents retained for the analysis.

In such case, it is evident that only the quantifiable critical incidents may be retained.

If the pursued objective is the choice of design, it is very important to compare the risks with various alternatives in terms of probable impact on the schedule, on costs and on various quality measures. Purely quantitative approaches would not totally reach this goal.

- The Available Resources

In the final analysis, the degree of sophistication of the risk analysis depends on available resources in terms of time, dependable data, expertise and statistical analysis software. At the lower end of the scale, one would find a project team dedicating one or two meetings to this subject depending on one set of tools only: blackboard and chalk and an expert on the subject if the team does not have the necessary experience. This level of sophistication has proven to be very valuable and should never be underestimated.

In the other extreme, a team of experts dedicated to this task on a full time basis for three or four weeks would use sophisticated software support.

All alternatives are possible and useful; the important thing is not the choice of the method but recognizing the necessity to evaluate the risks of your project with whatever resources available.

On a large long duration project, one can gain considerable benefits with the help of advanced statistical techniques such as sensitivity analysis and simulations. These techniques, for example, allow one to identify the critical incidents which contribute most to the global risk of the project and thus may reduce this uncertainty through a more thorough analysis of such incidents.

3. IDENTIFYING MEASURES TO MITIGATE RISKS

Risk mitigation measures can be divided into three categories:

- **Preventive measures** with the objective of reducing or eliminating the probability of a critical incident

- **Contingency measures** with the objective of reducing the negative impact should a critical incident occur

- **Control measures** with the objective of closely monitoring a risk factor in order to react quickly and efficiently

A) PREVENTIVE MEASURES

A preventive measure is possible if the owner or the contractor has a certain degree of control on the occurrence of a critical incident.

Table 2 includes some examples of such measures.

B) CONTINGENCY MEASURES

The object of contingency measures is to reduce the impact of critical incidents if preventive measures do not sufficiently reduce their probability. For example, in the case of "bankruptcy of a supplier", a contingency measure could be the identification of an alternative source of supply and even a provisionary agreement negotiated with such a supplier. In an actual case with particularly complex specifications, where such risk was considered, the owner decided to award the same mandate to two different suppliers.

The contingency measures most often employed by the construction industry are:

- insurance
- contractual transfer of risk

Insurance is used particularly to protect against risks arising from the physical environment (fire, theft, water damage) and any type of accident. The contractual transfers of risk between the parties ought to be given more serious consideration in view of the increase in disputes and litigation in the industry.

The main aim of the contingency measure is to share the risks either between a contractor and its insurer or between the owner and the contractor. In the eyes of some owners, the perfect contingency measure would be a total transfer of risks of several critical incidents to the contractor; for example, risks concerning soil conditions, climatic conditions, the quality of plans and specifications, etc.

However, it has been proven that such a perspective does not serve the owners' interests nor the projects. It merely creates: inflated tender prices, disputes, litigations, delays and finally, increased costs to owners and increased bankruptcies for contractors.

The appropriate contingency measure is therefore sharing the risks equitably, knowing well that, in principle, a risk should be assumed by the party most capable of controlling and managing it.

C) CONTROL MEASURES

The objective of this last type of measure is to monitor certain risk factors which are considered significant but where the critical incidents are especially difficult to identify or to evaluate a priori. For example, if there are certain doubts about a supplier concerning his ability to deliver a desired product within the expected timeframe and pursuant to the specifications, one can adopt or negotiate specific control measures with regard to inspection or quality audits.

CRITICAL INCIDENTS	PREVENTIVE MEASURES
• BANKRUPTCY OF A SUPPLIER	• choice of suppliers according to their financial status as well as the mechanisms they have in place to face such financial risks
• ACCIDENTS ON SITE	• Appropriate safety and security program
• SITE BURGLARIES	• Security system
• STRIKE	• Special agreements with labour unions
• CHANGED SOIL CONDITIONS	• Additional investment in geological reports
• DISPUTES WITH REGARD TO PLANS AND SPECIFICATIONS	• "Constructability" analysis prior to construction
• DISPUTES WITH REGARD TO CHANGES...	• Permanent arbitration board consisting of a third party (ADR)

4. EVALUATION OF THE COST/ BENEFIT RATIO OF THE IDENTIFIED MEASURES

Most preventive and contingency measures carry substantial implementation costs in terms of effort and dollars. Within this phase these costs must be evaluated and the decision made on which ones to retain, taking into consideration their contribution to risk mitigation.

5. IMPLEMENTATION OF THE SELECTED MEASURES

The retained measures, as a whole, constitute the plan for the risk management of the project which then has to be integrated within the global project plan, including its proper schedule and budget.

6. FOLLOW-UP OF THE MEASURES IMPLEMENTED

As with any other project activity, the risk management plan must be carefully controlled and continuously adapted to the changing conditions of the project environment.

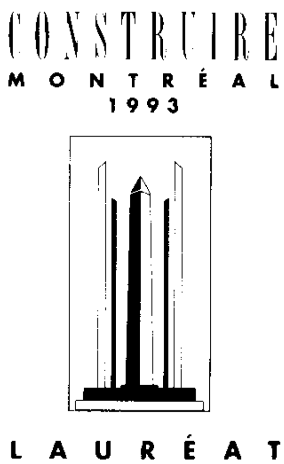
CONCLUSION

Risk management is increasingly considered an essential element of strategic project management, be it for the owner or the contractor. A simple scenario to fit even the smallest organization can be summarized as follows:

- Assemble a group of well-informed associates.
- Identify the critical incidents applicable to the project (patterned after Table 1).
- Evaluate the probability of incidents and their impacts based

on the experience and knowledge of the focus group.

- Utilize the brainstorming technique to identify preventive, contingency and control measures for the most significant risks.
- Evaluate the cost of these measures and retain those which are financially feasible.
- Implement the selected measures and monitor the changes.



QCA MONTREAL HONOURS DESERVING FIRMS

The Quebec Construction Association -Montreal Region honoured the high achievers of the year during a competition "Construire Montreal 1993". Among the six categories: General contractor with $35 million or more; General contractor with $35 million or less; Contractor specializing in architecture; Contractor specializing in mechanical and electrical work; Manufacturer/Supplier of construction materials, Revay and Associates Limited received the trophy in the category Manufacturer/Supplier of Services. This trophy was presented during the Quebec Construction Association's annual ball last April. RAL has been a member of the QCA since 1973 and has remained loyal to the Association to this day, showing the company's confidence in the Association. The jury of five took the following four criteria into consideration: dynamism, innovation, leadership and stable financial status.

RAL PRESIDENT, STEPHEN G. REVAY RECOGNIZED WITH NATIONAL STOLLERY AWARD

RAL President, Stephen Revay, became the fourth recipient of the Robert Stollery Award for leadership and excellence in Canada's construction industry at the Canadian Construction Association's 75th annual convention in March. This award is presented annually to an individual who has made an outstanding contribution to the growth and stature of the Canadian Construction industry by applying the highest standards and principles. S.G. Revay headed the CCA task force on R&D which reported to the Association's Board last year and recommended that a source of industry funding for R&D be set up. According to Steve, R&D is not the answer on its own; technology transfer is important as well. Moreover, Canadian firms are going to have to compete on an international scale and improving their construction knowledge is the best way to do that.

ERNEST C. JOHNS, P ENG. JOINS RAL

E.C. (Ernie) Johns joined the Ottawa Branch of RAL as a Senior Consultant on February 1, 1993. He was formerly president of Beaver Construction Ontario Division and is a director and past president of the National Capital Heavy Construction Association.

A resident of Ottawa since 1973, he joined the Beaver Group upon graduation from McGill University in 1961 as a civil engineer. Construction and Engineering run in the family - his father and both grandfathers were in construction. Ernie is a member of both the Association of Professional Engineers of Ontario and the Order of Engineers of Quebec.

His experience with the Beaver Group of Companies included sewer and watermain installations, tunnels and pump stations. It also included refinery work in Montreal and St. Romuald and mainline and distribution pipeline work in Ontario, Quebec and New Brunswick. He had considerable field involvement in these areas as well as estimating and administrative experience. His appointment significantly expands the Branch's capacity to serve clients in Eastern Ontario and Western Quebec as claims consultants and in the provision of project management services.

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