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Alliances decision-making in NPD: A risk point of view

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Abstract: During the bidding process a couple {product; projects} has to be formalized. To be competitive, the bid should present an innovative advantage while being achievable. Most often the time, if product is complex, a unique company doesn't have the whole competences to provide the complete product. Depending on the selected partners, different possible innovation level can be reached. This decision also influences the level of risk of the project. To be profitable, if the bid process is successful, the best couple {innovative product; reliable project} has to be selected. In this paper we present a decision support system for making alliances, based on a Decision Tree. The originality of the paper is to consider linked decisions focused on the collaborative network and on the risk management.

Keywords: design project, alliances, risk management, innovation.

1. INTRODUCTION

Designing a new product is performed in project-based teams. The new product development (NPD) is the result of a collaborative process between human resources belonging to different functions of a company or between companies working networked (Laubacher and Malone 2003). This can be done in particular bi-lateral relations or in clusters. Companies can collaborate with research laboratories (public or private), start-ups or even competitors then enters an open-innovation process (Chesbrough, 2003). In NPD project, companies are looking for making alliances and organizing into networks; each company brings specific expertise. Creating multidisciplinary project teams (with an array of skill sets and specializations) introduces new management and research challenges in harnessing the involved creative capital (Badke-Schaub et al. 2007, Townley et al. 2009). The need of creative capital is related to innovation level and to risks in NPD project.

In this paper we outline an approach for making strategic decisions on the choice of partners (alliances) in NPD projects, according to risk. After a short literature review, we present our model and the proposed approach. Then, a case study illustrates our approach.

2. ALLIANCES FOR INNOVATIVE PROJECT

2.1 Alliances in NPD

The choice of collaboration is determined in order to reach a potential for innovation in NPD projects (Das and Teng 1998, Backman et al. 2004, Emden et al. 2006). This potential derives from the cognitive distance between potential stakeholders. Nooteboom et al. (2007) describes the inverse-U-shaped benefit-distance relationship which arises from the

trade-off between absorptive capacity and novelty gain. These authors take into account the costs of alliance formation, in which alliances are profitable.

Several authors distinguish three design types according to the initial innovation level. Designers begin their works with the assumption that the design output is either creative, innovative or routine, and then provide efforts based on this assumption. This classification is adapted from Gero's classification (1990). Pahl and Beitz (1996) emphasize the novelty of the solution principle and technology to distinguish different types of design problems. Evbuomwan et al.'s classification (1996) ordered design process by increasing the level of originality from routine design, to redesign and non-routine design. In reality, it is often not possible to define precisely the boundaries between the three types of design. For example, a complex product is composed by different sub-systems. One of sub-systems maybe corresponds to innovative design, while another is routine design. Therefore, this should be considered to be only a broad classification.

Altshuller (1994) define five degrees of inventiveness and show the correlation between level of innovation and the extent of the necessary knowledge:

Level 1 – Routine design, usually no invention needed.

Level 2 – Minor improvements to an existing system using methods known within the industry. This implies a need to make alliances.

Level 3 – Fundamental improvement to an existing system using methods known outside the industry. This implies a need to make alliances.

Level 4 – A new generation of a system that entails a new principle for performing the system's primary functions.

Solutions are found more often in science than technology. This implies a need to make alliances.

Level 5 – A rare scientific discovery or pioneering invention. This implies a need to make alliances with the inventor's firm.

The complexity of technical systems resulting from design raises rapidly as demands for function, cost, quality, increase. Greater the complexity, the more difficult it is to achieve integration among various subsystems in an organization (Gupta et al., 1986). Due to the high complexity, technical systems are vulnerable to failures, leading to costly repairs, environmental damages, and human casualties (Lu & Shu, 2009). Uncertainty generated by the problem-solving activity makes the design process inefficient, in the sense that costly rework loops tend to multiply (Nightingale, 2000). As a consequence, risks that can happen during NPD project have to be anticipated.

2.2 Project risk management

In the literature, the risk management methodologies refer to a standard process presenting the well-known steps: risk identification, risk evaluation and quantification, risk mitigation for treatment and/or impact minimization and risk monitoring (BSI, 2000; ISO31000, 2009). Tixier *et al.* propose a classification of sixty-two existing approaches (Tixier, 2000). They sort methods depending on whether they are deterministic and/or probabilistic, and also whether they are qualitative or quantitative. Within the context of a project, a risk occurrence may introduce: (1) the modification of existing tasks related to the risks influencing on duration or cost. (2) the modification of the project structure by risk treatment strategies. This therefore impacts the project planning: cost and duration. The specificities of the project context are: the notion of uniqueness, the notion of limited horizon (different milestones and contractual commitments), and the notion of a multi-expertise environment (different actors).

In parallel to these global approaches, several authors propose methodologies to manage the risk in projects (Gourc, 2006). Risk is described as an event, which has occurrence characteristics (potentiality to occur) and consequence characteristics on the project objectives (impact in the event of occurrence) (Carter, 1996). The risk level also labelled criticality is then obtained by multiplying the probability of the event and its impact (BS 5760-5, 1991). Project management and risk management processes are generally presented as independent. Nguyen et al. propose the method ProRisk, supported by a software tool (available online at <http://prorisk.mines-albi.fr>) that assists in modelling and evaluating the impact of risks on the project cost and the schedule cost (Nguyen et al. 2013). They define the concepts of risk scenario, treatment scenario and project scenario.

The project management of new product development (NPD) is well-known for its reference to the innovation. Risks are intrinsic in NPD in all industries (Kwak et Laplace 2005). Thus firms need to take initiatives to reduce risks that are related to NPD. In NPD management, decision-makers have to choose exclusively one orientation as strategy development

according to a global risk level tolerance. As an answer, decision trees (DT) are regularly used in the literature on decision (Chiu et al. 2006). In the context of the bidding process, Botero et al. (2012) consider the feedback to shape the best answer. To increase the efficiency of innovation in such process, the link between the choice of the partners and project risk management has to be made.

3. PROPOSED APPROACH

In this work, we focus on the decision making process in design project management and risk management by analysing the consequences of the risk "as an event" in the exploratory design project. The use of DT permits us to formalize the successive decisions made by a decision maker.

Little account is taken of the risks and the strategies to deal with the selection of the collaborators and their repercussions on the design project. Moreover, there are no tools helping the project manager evaluate the solution of the project design problem and its consequences on (1) the innovation level of the product, (2) the risk level of the project.

By taking into account the fact that well-managed risks lead to better NPD performance, our objective is to propose a complete framework helping decision-makers to decide innovation and risk treatment strategies. Our approach should facilitate the decision-making processes by creating links between project management, risk management and design management and by showing the consequences of the collaborative network on the planning and on the risk (the risk itself and its treatment). This process allows us to view the consequences of the decisions.

The various possible scenarios and their evaluations will be presented to the project manager. A decision process will make it easier to find the appropriate technological solution and the needed risk treatments.

3.1 Assumptions

The proposed model is based on two main assumptions. (1) the risk can affect the duration and the cost criteria for the project. (2) When the collaborator is chosen, the tasks list and the risks list are known.

At any time, the objectives of the model are to calculate the possible scenarios and their associated indicators.

3.2 Formalization of the decision process in the bidding process

After having identifying innovative technological solutions, the first decision is to select skilled partners. The choice of the partner will influence the innovation level. Typically, several options are possible.

For each one of these solutions, it is possible to draw up a plan using the Project Planning Process (PPP). Based on the selected plan the Project Manager (PM) has to organize the treatment of the risks over the design project. In that way, the next decision consists in choosing the preventive risk treatment strategy in the chosen collaborative project. The Risk Management Process (RMP) is performed to identify

the risk treatment and the PPP is developed a second time to plan the risk treatment tasks as well as to integrate others modifications to the plan. These two decisions are made in the preparation phase of the project.

The PM has also to plan the possible project development. In that way he has to consider the possible occurrence of risks. For each possible set of occurrences, the decision of corrective strategies that could be carried out during the whole design project (from the requirement specification phase to the validation phase) has to be made. After that decision, the RMP and the PPP are supposed to be reprocessed as well as to integrate new information and to obtain the final planning.

3.3 Objectives

When different possible collaborations are studied to satisfy the same need, the repercussions on the risks are rarely anticipated in the classical approach. The project manager has to consider the profitability and the innovation level of the studied collaboration, but also the consequences with regard to the risk level. The selection is a multicriteria problem. When the project manager makes the decision, the number of criteria used to evaluate the proposal is often reduced to the main ones: the cost, which is a sensitive and finite resource, and the duration, which traditionally is a matter of contractual commitment. These criteria are not totally independent. In this study, to be able to handle the potential contractual cost overruns and delays, as well as the probability that different events occur, choices must be made in order to characterize project scenarios. The innovation level of the collaboration is also considered. Then decisions are based on an analysis of the criticality versus innovation level.

3.4 Data

P^{nk} ($nk=0, \dots, NK$) is a Project associated to a particular network nk , NK being the number of possible network and then potential projects. Each nk permit to reach an Innovation Level IL varying from 1 to 5 of technological solution. 1 being not particularly innovative and 5 being fully original and giving a real advantage to the bid.

Each P^{nk} is described by its tasks T_i^{nk} ($i=1 \dots T^{nk}$), T^{nk} being the number of project tasks of P^{nk} . The planning process gives an initial planning P_i^{nk} that does not integrate any risks. A project is also described by its set E_R^{nk} of identified risks R_i^{nk} ($i=1 \dots n^{nk}$), n^{nk} being the number of identified risks in P^{nk} . Each R_i^{nk} is characterised via the risks management process. A risk R_i^{nk} is also characterized by its period of occurrence, i.e. the tasks during which the risk can occur. It has a probability $proba(R_i^{nk})$ (the probability that the event related to R_i^{nk} occurs) and impacts in costs $CI(R_i^{nk})$ and/or in duration $DI(R_i^{nk})$ on a task. This task can be different from the period of occurrence. These probability and impact are also called initial probability and initial impact. The initial impact allows consideration of the fact that the task is running in a graceful degradation.

A risk scenario ScR_s^{nk} corresponds to a combination of the risks that are considered as occurring during a project P^{nk} . A

project presenting n risks leads to 2^n risks scenarios. Then ScR_s^{nk} ($s=1, \dots, 2^n$) is a possible achievement with k risks ($0 \leq k \leq n$) and the total number of risk scenarios, presenting k of the n identified risks, is equal to $n!/k(n-k)!$. It has a probability $proba(ScR_s^{nk})$ (the probability that the events related to this risk scenario occur and that the other risks do not occur).

$$proba(ScR_s^{nk}) = \sum_{i=1}^n \begin{cases} proba(R_i^{nk}) & \text{if } (R_i^{nk} \in ScR_s^{nk}) \\ 1 - proba(R_i^{nk}) & \text{if } (R_i^{nk} \notin ScR_s^{nk}) \end{cases} \quad (1)$$

Each risk can be treated in various ways that can be preventive, corrective or a combination of several actions. A risk R_i^{nk} can be associated to one or more treatment strategies StT_{ij}^{nk} ($j=1 \dots m^{nk}$), m^{nk} being the number of identified strategies for R_i^{nk} . A treatment strategy StT_{ij}^{nk} groups a set of treatment actions A_{ija} ($a=1 \dots a$) to avoid or reduce the risk R_i^{nk} , a being the number of identified treatment actions. A treatment action can be materialized by a task to achieve and it can introduce three types of modification to the WBS: (a) addition of a new task, which generates a new action to be implemented; (b) suppression of a task from the initial schedule. The risk is reduced by suppressing a task from the schedule; (c) modification of an existing task.

A treatment strategy is a preventive strategy if it contains at least a preventive treatment action. Otherwise, it is a corrective strategy. If the strategy consists in running no action at all, it is noted as being an empty set such as \emptyset (i.e. graceful degradation).

The treatment actions can be common to several risk treatment strategies. The set of all the identified StT_{ij}^{nk} for a risk R_i^{nk} is written StR_i^{nk} .

$$\text{Then } StR_i^{nk} = (\emptyset, StT_{i1}^{nk}, \dots, StT_{ij}^{nk}, \dots, StT_{im}^{nk}) \quad \text{and} \\ \text{Card}(StR_i^{nk}) = m^{nk} + 1.$$

A treatment scenario ScT_d^{nk} ($d=1 \dots D^{nk}$) corresponds to a combination of the treatment strategies chosen to deal with the different risks of P^{nk} . The set of treatment scenarios is given by: $E_{ScT} = \sum_{i=1}^n StR_i^{nk}$. For each P^{nk} , E_{ScT}^{nk} may contain a set of preventive treatment scenarios $E_{ScT_{prev}^{nk}}$ and corrective treatment scenarios $E_{ScT_{correc}^{nk}}$.

The $proba(R_i^{nk} | StT_{ij}^{nk})$ is the probability that the event related to R_i^{nk} occurs knowing that StT_{ij}^{nk} (preventive strategy) has been done. This probability, as well as the impacts $CI(R_i^{nk} | StT_{ij}^{nk})$ and $DI(R_i^{nk} | StT_{ij}^{nk})$, are then qualified as "reduced".

A project scenario ScP_p^{nk} ($p=1 \dots P$) is defined as being a possible project achievement that is built with a risk scenario and treatment scenario ($ScP_p^{nk} = \langle P_i^{nk}, ScR_s^{nk}, ScT_d^{nk} \rangle$). The set of project scenarios ES^{nk} is obtained by combining the set of risk scenario and the set of treatment scenario.

$proba(ScP_p^{nk})$ is the probability of a given ScP_p^{nk} . It takes into account (2) the probability of the occurring risks ($R_i^{nk} \in ScR_s^{nk}$), (3) the probability that several risks does not occur ($R_i^{nk} \notin ScR_s^{nk}$), (4) the probability of the occurring risks ($R_i^{nk} \in ScR_s^{nk}$) knowing that a treatment strategy is developed ($StT_{ij}^{nk} \in ScT_d^{nk}$) (5) the probability that R_i^{nk} does not occur ($R_i^{nk} \notin ScR_s^{nk}$) knowing that a preventive strategy has been

processed and the initial probability has been modified ($StT_{ij}^{nk} \in ScT_d^{nk}$).

$$proba(ScP_p^{nk}) = \prod_{i,j}^{R_i^{nk} \in ScR_s^{nk}, StT_{ij}^{nk} \in ScT_d^{nk}} \begin{cases} proba(R_i^{nk}) & (2) \\ 1 - proba(R_i^{nk}) & (3) \\ proba(R_i^{nk} | StT_{ij}^{nk}) & (4) \\ 1 - proba(R_i^{nk} | StT_{ij}^{nk}) & (5) \end{cases}$$

The cost of a project scenario is noticed $C(ScP_p^{nk})$. It includes the cost of the T^{nk} tasks that constitute the initial planning of the project, the ScR_s^{nk} and the chosen ScT_p^{nk} and (6) The Global Cost $GC^{initial}(R_i^{nk})$ of the occurring risks that are not treated by the treatment strategies. It includes the cost impact that is composed by a fixed part of the total cost (materials, tools, parts, etc.) and by an indirect cost that depends on the action duration, through the Delay Impact, and the actors charge. (7) The reduced global cost impact $GC^{reduced}(R_i^{nk})$ that is obtained taking into account the different strategies StT_{ij}^{nk} applied to treat R_i^{nk} and its reduced repercussions on the project cost and duration. (8) The cost of the treatment strategies StT_{ij}^{nk} that is determined by the cost of the action is composed by a direct cost (materials, tools, etc.) and by an indirect cost that depends on the action duration and on the actors.

$$C(ScP_p^{nk}) = \sum_{i=1}^T C(T_i^{nk}) + \sum_{i,j}^{R_i \in ScR_s^{nk}} \begin{cases} GC^{initial}(R_i^{nk}) & (6) \\ GC^{reduced}(R_i^{nk}) | StT_{ij}^{nk} & (7) \\ \sum_{StT_{ij}^{nk} \in StR_i^{nk}} C(StT_{ij}^{nk}) & (8) \end{cases}$$

Each ScP_p^{nk} can be characterized by a criticality $Cr(ScP_p^{nk})$. This criticality measure is based on its probability of occurrence $proba(ScP_p^{nk})$ and its $impact(ScP_p^{nk})$. $impact(ScP_p^{nk})$ is calculated based on a duration and a cost metrics of the project scenario respectively α_p^{nk} and β_p^{nk} :

$$\alpha_p^{nk} = \frac{DI(ScP_p^{nk})}{\max(DI(ScP_p^{nk}))} \quad \text{and} \quad \beta_p^{nk} = \frac{CI(ScP_p^{nk})}{\max(CI(ScP_p^{nk}))} \quad (p = 1, \dots, P),$$

$$(nk=0, \dots, NK) \quad (9)$$

then $\alpha_p^{nk}, \beta_p^{nk} \in [0, 1]$.

Where $CI(ScP_p^{nk})$ and $DI(ScP_p^{nk})$ are respectively the distance between the Cost and Duration Impacts and the budget and duration thresholds defined in the contractual agreement of the project. $\max(CI(ScP_p^{nk}))$ and $\max(DI(ScP_p^{nk}))$ the distance of the costly and longest project scenario possible over the whole design project.

The global impact, weighted and normalised, $Impact(ScP_p^{nk})$ is then obtained through the following formula:

$$Impact(ScP_p^{nk}) = q \times \alpha_p^{nk} + q' \times \beta_p^{nk} \quad (10)$$

Where q and q' (respecting $q + q' = 1$) are two coefficients that are chosen by the project manager in accordance with the importance of the duration relatively to the cost.

Then, $\forall p, \forall ts, Cr(ScP_p^{nk}) = proba(ScP_p^{nk}) \times impact(ScP_p^{nk})$ (11)

4. RESOLUTION APPROACH

In the preparation phase of the bidding process, the collaborators required to achieve innovative components need to be selected. The project, including tasks of risk treatment depends of this decision. The approach we propose uses data relative to the project in its classical view: the

different tasks are planned, the risks identified, and the associated treatments prepared. This approach also uses data relative to the potential collaborators and the consequence of the choice: namely modification of the project and the associated modification on the risks. The method includes input data provided by the schedule process (management team) and from the risk management process;

The main approach has two phases: (1) the construction of the Decision Tree (DT), from the first decision node to the leaves, (2) the resolution of the DT by working backward method.

4.1 The construction of the DT

The generation of the DT consists in building the set of possible project scenarios in light of the identified risks and risk treatment actions and their evaluations for each technological solution studied. The project scenarios are the leaves of the tree. To evaluate the different possible project scenarios, the management team needs to generate an initial schedule for each technical solution, without integrating the notions of risk and risk treatment. Depending on the difference between the technical solutions, the outcomes can be rather similar or rather different.

Next to each collaborator selection, it is then necessary to calculate the different risks and treatment scenarios. These scenarios allow the set of the project scenarios to be constructed. Finally, when the project scenarios are known the times and costs are calculated for each case. This approach based on ProRisk, proposed in (Marmier et al. 2013, 2014), is then used to generate ES^{nk} . Once the initial schedules have been adapted in accordance with the studied scenario (modified duration, tasks added or removed), the project scenario duration is computed using the PERT method and the earliest starting dates.

4.2 The resolution of the DT

The backward method's resolution consists in studying the effects of the different decisions from the leaves to the root of the tree. Through the use of this knowledge it is possible to become proactive. Therefore, the number of steps of this phase depends on the number of decisions in the DT: 3 for the problem under consideration.

Step (1) consists in finding for each branch of the DT, the best corrective treatment for each risk. In each branch, the collaborators and the preventive treatment are known and the best corrective treatment can be determined. D3 is made by choosing the corrective strategies that minimize $Cr(ScP_p^{nk})$ for all the leaves of the tree.

Step (2) D2 is the second step that composes the selection phase. D2 determines the preventive treatment strategy that is the most adequate for each technical solution. Minimizing the maximum criticality (also called in a similar context regret) can, when the assessment of each scenario is known, measure the regret that the decision-maker would have if he had preferred one action over another. D2 is made by choosing the preventive strategies that minimize $Cr_{max}(ScP_p^{nk} | ScT_{prev}^{nk})$, knowing the selections realized in D3.

Step (3) D1 is the selection of the best network. The project management team wants to maximize the chance of meeting the commitments if the bidding process is successful. D1 consists in selecting the collaborators that maximizes the number of possible ScP_p^{nk} respecting the potential contracted duration and cost.

5. APPLICATION IN THE SATELLITE INDUSTRY

The project scenarios go from the needs analysis to the time when the satellite reaches its final orbit.

Presentation of the satellite design project

The application case, developed here to illustrate this research work, considered the bidding process of the development of a small satellite for a scientific mission. The main company doesn't have all the competences and potential partners are already identified: the company A will achieve the measuring equipment (functional architecture and detailed design; Case 1) either the company A or B can achieve the innovative communication equipment (Case 2). Company B permits to reach a higher innovative level but it makes the network more complicated; it induces time for sharing information and risks associated to these tasks. By keeping company A for all subcontracted activities, time and budget can be saved. To succeed the bidding process, it is important to design a network leading to the best couple {reliable project; innovative product}.

15 phases are identified for this project. The phase durations are presented in Time Units (TU) with a fixed rate and their costs in Monetary Units (MU). Conflicting requirements complicate the project. For example, the need for high onboard power (>100 W), a low satellite mass (<120 kg), a low volume (<1m³), a long life time (>2 years)...

Contractual commitments of the bid will be established at 37 TU and 44 MU for this project. There are risks associated with either of the two networks. A shortlist of 4 risks has been selected for the application case. Their modifications are representatives of the network choice effect.

Their associated cost is a fixed cost that is added to the one based on the new task duration. Possible treatment strategies characterize them. The impacts of one risk are judged as infinite since the costs and delays will continually increase until an action is decided. As an example, the risk R4, expresses the anomaly observed during the material integration on the satellite (error of wiring, systems presenting default...). If such a risk occurs, the production is immediately stopped until a strategy is implemented. Then two strategies are possible in both versions of the project: a preventive one and a corrective one. StT_{41}^A and StT_{41}^B , consist in carefully checking the actual components constructed by the subcontractor as both the manufacturer and the subcontractor carry out the reviews, auditing etc. If it did not completely eliminate the risks, it reduced their probability of occurrence by 10%. The cost of these actions is estimated at 2 MU for planned modifications that are not located on the critical path.

6. RESULTS AND DISCUSSIONS

The results obtained with this approach show the effect of the successive decisions made during the bidding process (collaborative network and preventive strategies). For example, it is possible to decide that the preventive strategy consists in undertaking no action. As an illustration of the results, the number of project scenarios to be considered in the case of the collaboration with the company A is 20 (case 1). In the other case of communication equipment, 970 scenarios have to be studied to evaluate both the pertinence and the risk level of working with companies A and B (case 2). Making decision is then difficult. By working only with company A (case 1), 9 project scenarios are non-pertinent since one or more risks that occurred are inapplicable. 420 project scenarios are non-pertinent in the case 2. These projects are stopped without any corrective strategies despite the presence of possible preventive strategies. Then a corrective strategy should have been applied. The maximal criticality among the pertinent scenario is calculated. It identifies undesirable scenarios. Still, among the pertinent scenarios, the approach permits to identify the percentage of scenarios that would respect the contractual commitments. Then it is possible to identify the collaborative network that maximizes the number of project scenarios in the agreement zone. This result means that by choosing the collaborator A and by applying no preventive treatment strategy, 67% of the pertinent project scenario respects the contractual commitments of the bid. Based on these results, the recommendation to the project manager would be simple: collaborate only with A and apply no preventive strategy. But this decision has to be made knowing the fact that the innovation level would be lower with this network and thus the bid could be less attractive. The whole results and details will be presented during the conference.

Concerning the method, the universe of the events that may happen during a project is important. Events characterization and their effects necessitate having and manipulating a large quantity of information. It is one of the elements that confer to our model a proximity to reality. Therefore, it is necessary to have and to be able to manipulate this information if we want to explore the set of the possible futures for large project, in order to assist the decision maker. Then, the need to characterize possible futures for the project leads to the necessity to build a model rich in information.

The results of the application case have been presented and discussed with industrial partners. The approach presenting successive steps of planning and risk integration is representative of industrial projects. The decisions proposed following the approach were consistent with their perceptions of what were the best decisions in the studied context. The application case is simplified for the sake of the demonstration. The approach is flexible since it can be used in a different context.

7. CONCLUSIONS

In NPD the creation of a collaborative network has an influence on the innovative level of the project. Therefore it also has repercussions on the project and its risk level. The antagonism of the innovation level versus the risk level, in

the preparation phase of a project makes decision quite complex. Each possible decision generates different plans with different costs, durations as well as different risk levels. To estimate the risk level for each project variant, we propose an approach to model and evaluate the impact of risks on the project cost and the schedule cost. We illustrate the principles of our approach through an application case from the aerospace industry. This methodology analyses the possible scenarios of collaboration and evaluates the global risk level. We have developed a software tool that illustrates this process. As the occurrence of a risk can modify the project, due to a new context, the remaining risks can change and new risks can occur. This work leads to a pre-condition of collaboration in NPD project and consequently helps to the decision-making. Next, it is necessary to confirm the feasibility with the potential collaborators. This step should help to validate the availability of the critical resources involved in the future project.

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