Risk management

Diagnosing risks in product-innovation projects

J I M Halman and J A Keizer

Graduate School of Industrial Engineering and Management Science, Eindhoven University of Technology, PO Box 513, 5600 MB Eindhoven, Netherlands

A new method of diagnosing risks in product-innovation projects is introduced in the paper. The method is an improvement on existing risk methods used on product-innovation projects, such as potential problem analysis and failure mode and effects analysis. Technological, organizational and commercial risks are identified and assessed on an individual basis. These risks are mapped in a risk topography which is used as an input for the drawing up of a risk-management plan. The method has been developed on the basis of case-study investigations, and applied in various product-innovation projects in the Netherlands and in Germany.

Keywords: risk diagnosis, product innovation, risk management, risk topography

Product innovation is one of the most risky activities in business:

- About 35% of products launched fail commercially¹.
- Approximately 45% of total new-product expenditures are on unsuccessful projects².

Despite all the research on the success and failure of product-innovation projects executed in the last 20 years, improvement of the success rate still seems difficult to achieve. Disappointments and failures in the realization of product-innovation projects are often due to a naive but optimistic attitude towards a perceived gap between available and required knowledge and skills. *Figure 1* illustrates in a made-up graph how, in successively executed projects P_1 , P_2 and P_3 , knowledge and skills have increased, and that, in a potential new project P_4 , capabilities are required that are not or are not yet available. To achieve a careful diagnosis and management

of risks, an accurate detection of the gap between available and required knowledge and skills is crucial.

Background

The Risk Diagnosis & Management (RDM) method which is described in this paper has been developed through case-study investigations within two divisions of a multinational company. One is a supplier of glass parts for the audio and video industry, and the other operates in the lighting industry.

The development of the method was initiated with an extensive evaluation of one major product innovation project within Philips Glass. On the basis of this evaluation, a first version of a company-specific RDM for product-innovation projects was created within Philips Glass (see Reference 3).

The development was continued within Philips Lighting. In this division, the RDM was improved and tested on product-innovation projects which were regarded as important to the company. At the end, a manual for the RDM developed was drawn up for the internal project consultants of Philips Lighting. On the basis of the results, the senior vice president (R&D) of Philips Lighting decided to include the method in the company's standard product-innovation procedures.

Since then, the RDM has been applied in the product-innovation projects of industries that develop and produce such products as automobile tyres, ship propellers, printing equipment, and equipment for optical-storage media.

The RDM is executed by a project consultant on the request of the project management. To carry out the

Figure 1 Acquired and required knowledge, skills and experiences in subsequent projects

Figure 2 Outline of Risk Diagnosis & Management method

RDM, a risk team is formed. This team consists of the members of the project team, and is extended if necessary with external experts.

In Figure 2, the RDM method is outlined. In the following paragraphs, some of the main characteristics of the method are discussed.

Identification of project risks

The purpose of a risk diagnosis is to detect those factors which may jeopardize the successful realization of the project objectives. In product-innovation projects, these factors can be differentiated in terms of their technological, organizational and commercial factors^{4,5}. Specific to the RDM approach is the focus on the detection of gaps between available and required technological, organizational and commercial knowledge, skills and experiences. Specific also is that, in RDM, data are gathered by the project consultant through individually interviewing the members of the risk team.

To identify the project risks, the following three activities are carried out.

- *Description of product, process, equipment and production system:* Technological risks can have a bearing not only on the product characteristics and the operating production system, but also on the process, the

equipment, the tools and instruments, and the control programs to be developed or adjusted⁶. All of these aspects should be analysed separately as well as in terms of their mutual relationships. For this reason, a systematic description has to be created of the required product components, the processes required to manufacture the product components, and the necessary equipment and tools that are required, as well as the relationships between these elements. In the interviews, the members of the risk team are asked to describe these elements in general, and specifically their personal contribution in this respect.

- *Identification of technological gaps:* On the basis of the systematic description, the interviewees are asked to indicate gaps between available and required knowledge, skills and experience. These gaps are perceived as potential technological risks. As an example, if a project team is working on a new burner with a new type of filling gas, there is a potential technological risk if the team does not or does not yet know how the contamination of the dose-measurement materials should be handled.
- *Identification of organizational and commercial gaps:* In the risk-identification process, the focus is also on the identification of the organizational and commercial factors which may jeopardize the successful realization of the project objectives. Research in the area of critical success factors in project management and product innovation has made it clear^{4,7-9} that a project's success depends on both internal circumstances and external influences. In Figure 3, a model is presented in which these internal and external influences are summarized. The model indicates which factors it is important to consider during these interviews. This is a general model; depending on the situation of a specific product-innovation project in a specific organization, one should specify the relevant variables in the project environment.

Internal circumstances relate to

- *formulation of project goals to be realized by project:* formulating the objectives and scope;

Figure 3 Model to identify organizational and commercial potential risk factors

Table 1 Example of part of risk questionnaire

Items with identified gap between current and required knowledge, skills or experience	The solution is as follows					Considering the required skills, knowledge, experience, the solution will be realized within time and resource limits					Relative importance to project success				
	Unknown	Chosen feasibility not yet proven	Specified and feasible	Tested: in experiment	Tested: in industrial setting	No		Yes			No		Yes		
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Contamination of dose-measurement materials	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Testing criteria	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Mutual-effect heat development burner/reflector/frontglass	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

- *specification of project goals*: making goals operational through technical specifications, and by specifying budgets for the spending of time and money;
- *organization of project goals*: drawing up a project plan that directs the allocation of time, money and people, splitting up the total project into separate subtasks, and arranging the various responsibilities and competencies within the project;
- *realization of project goals*: monitoring the actual realization of the project.

External influences from the project environment are related to the following:

- *parent organization*: priorities, support and availability of resources;
- *holding organization*: specific values and norms within the corporate company;
- *customers*: the customer's demands, and the benefits of the product for the customer;
- *market*: sales potentials and commercial benefits;
- *competitors*: competitors in the same and related fields, and product advantages compared with competitive products;
- *subcontractors*: adding relevant knowledge and skills to the project.

Valuation of project risks

Once the potential technological, organizational and commercial risk factors have been identified, the focus in the risk-diagnosing process changes from identification to valuation of the project risks.

Evaluation of risk factors via risk questionnaire

The impact of a risk factor is usually described as depending on its likelihood of occurring and the consequence if it does occur¹⁰. Although the focus of most risk analyses is on managing risks, the management aspect remains implicit in the concept. Risks are estimated separately from the management measures that can be taken. In RDM, the assumption is made that the impact of a risk not only depends on the likelihood of its occurrence and the consequence if it does occur but also on the ability or the inability to influence the situation. This

implies that an activity is labelled risky if it complies with the following:

- The likelihood of it occurring is great.
- The ability to influence the course of action is small.
- The potential consequences are severe.

In order to assess the identified potential technological, organizational and commercial risk factors, these factors are transformed by the project consultant into 'statements' and included in a risk questionnaire. The members of the risk team are subsequently asked to give their judgment about the riskiness of the different statements in the questionnaire. Table 1 presents the format of the risk questionnaire.

In line with the risk characterization created above, the technological statements are scored on the basis of three evaluation parameters:

- *likelihood of it occurring*: the certainty to create an appropriate solution, ranging from 'the solution is unknown' to 'the solution has been tested in an industrial setting';
- *ability to influence course of action*: the ability to realize the solution within time and resource limits;
- *potential consequences*: the importance of the issue concerned for the overall success of the project.

For the organizational and commercial statements, the same three evaluation parameters, although they are slightly differently formulated, are used. The judgment takes place by means of three five-point scales.

Drawing up a risk topography

The responses of the members of the risk team are processed and compiled in a risk topography. Every statement from the risk questionnaire is included and reported with its respective scoring for the three risk-evaluation parameters (see Figure 4). This representation indicates to what extent the majority of the interviewees interpret a certain statement as risky, and to what extent the opinions are distributed. Although the criterion can be chosen differently, we have chosen to mark with a dot the column in which a support of a minimum of 50% is reached.

Internal aspects of the project		certainty					influence project team					relative importance to project success					risk score	risk class					
		NO					YES					YES							NO				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5			1	2	3	4	5
1. The production/target (5000 units) will be reached	n resp	1	3	4	1	0	4	1	3	1	1	1	2	3	2	1	???	L - H					
	cum%	11	44	89	100	100	40	50	80	90	100	11	33	67	89	100							
	50%SC																						
2. The end user demands are known and will be met in this project	n resp	3	2	4	0	0	4	2	3	0	0	3	3	1	1	0	***	F					
	cum%	33	56	100	100	100	44	67	100	100	100	38	75	88	100	100							
	50%SC																						
3. The roles, tasks and responsibilities are well defined, clear and appropriate	n resp	1	1	2	3	0	2	2	0	4	0	5	0	2	0	0	? **	M - F					
	cum%	14	29	57	100	100	25	50	50	100	100	71	71	100	100	100							
	50%SC																						

Figure 4 Example of part of risk topography

For every risk statement, two more processings of the scores are executed:

- For every risk statement, the scores for the three evaluation parameters are summarized and expressed as a 'risk score'.
- For every risk statement, the three risk scores are combined and classified into a 'risk class'.

The scores can be summarized and expressed as a risk score by examining the distribution of the respondents' scores over the five-point scales. Four possible outcomes can be distinguished for every risk-evaluation parameter by using the following decision rules:

- *Consensus on high risk ('+')*: This means that at least 50% of the scores is found in the first and/or second columns of the five-points scale, and none in the fifth column.
- *Consensus on low risk ('0')*: This means that at least 50% of the scores is found in the fourth and/or fifth columns, and none in the first column.
- *Consensus on medium risk ('M')*: This means that at least 50% of the scores is found in the third column, and none in the first and/or fifth columns.
- *Lack of consensus on risk ('?')*: This means that (for all the remaining cases), there is a wide distribution in the opinions, or remarkably deviating opinions. After discussions with the interviewees the '?' scores may be changed to '+', 'M' or '0'.

Every risk statement can be subsequently classified into a risk class by looking at the combined risk scores on the three risk-evaluation parameters. In the RDM method, there are five risk classes: S = safe, L = low, M = medium, H = high, F = fatal risk. The combination +, +, + can be classified as extremely risky. Not solving such a risk is fatal for the project (risk class F). The combination +, 0, + can be classified as highly risky (risk class H), and the combination 0, 0, 0 indicates that, with respect to this aspect, the project is safe (risk class S). If the opinions are distributed, the risk score can be represented by a range between the lowest and the highest risk class that can be reached if the respondents would, after discussion, achieve consensus (for example L-M,

H-F etc.). In this scheme, the total number of possible combinations is $4^3 = 64$. In the RDM manual, these 64 combinations are worked out.

Quantifying risks for project as a whole

Additionally to the outcomes that are available from the preceding steps, one might want to quantify the risks for the project as a whole. This composite measure can be determined if one awards a weight to each of the risk classes. After this, the total project risk can be projected on a 0–100 risk scale. Looking for plausible weights for the distinguished risk classes, three assumptions are made:

- The risk classes represent positions on a risk dimension ranging from 'safe' to 'fatal'.
- The positions on this risk dimension have equal distances from each other.
- The risk class S is assumed to be safe, and is given the weight of 0.

Applying these assumptions, the different classes can be valued as follows: S = 0, L = 1, M = 2, H = 3 and F = 4. The risk statements are summed by risk class (F, H, M, L and S), and multiplied by the corresponding weights.

The maximum 100 risk score is reached if all the statements of the risk topography are found in the F class, weight 4. The minimum 0 score is reached if all statements are in the S class. The calculated risk value for a specific project can now be determined. Often, statements will be found with distributed opinions in the risk topography. Then one can establish a pessimistic and an optimistic scenario. The pessimistic scenario is calculated by assuming that all statements will eventually end up in the most unfavourable risk class (e.g. L-H becomes H, M-F becomes F). For the optimistic scenario, the opposite is assumed (e.g. L-H becomes L, M-F becomes M). See Figure 5 for an example.

Decision making about diagnosed risks

After the technological, organizational and commercial risk factors have been diagnosed, various process approaches can be followed to analyse and tackle these risks further:

- *Individual preparation*: Members of the project team,

Figure 5 Graphic representation of project risk on 0–100 risk scale

which is expanded if necessary with experts, are asked to analyse further the causes and consequences of the diagnosed risks and to find appropriate risk measures. The individual suggestions may then be discussed in a plenary session of the project team or worked on by the project manager.

- **Preparation by subgroups:** Special subgroups consisting of members of the project team, which is expanded if necessary with experts, are asked to think about risk measures for specific project risks. These subgroups are formed on the basis of their expertise relating to the diagnosed specific project risks. As in the individual approach, the results can either be discussed in a plenary session of the project team or further processed by the project manager.
- **Plenary session:** The causes and consequences of the diagnosed project risks are analysed in a plenary session of the project team, which is extended if necessary with experts. The plenary session is also used to decide upon the risk measures to be taken.

It depends on the specific situation of the project and the project team what approach will be favoured. Concerning the content of the decision-making process, there are four basic approaches to dealing with the diagnosed risks: reduce, transfer, reject and accept (see, for example, Reference 10).

Drawing up and execution of risk-management plan

The diagnosed risks and the measures required to tackle each one of them are brought together in a risk-management plan. This plan enables the management to decide upon the feasibility of the project, and to take a go/no-go decision. In the risk-management plan, the time and resources needed to execute the risk measures are worked out, and the responsibilities for the execution of these measures are proposed.

Since the risk measures will eventually be included in the total project plan, the possible consequences of the risk measures for the existing project scope, project plan and project budget have to be analysed. This may imply a readjustment of budgets and deadlines, but also the project scope and project organization may change considerably. Upon completion, the risk-management plan is reported to the project principal, after which it may be discussed, and a go/no-go decision can be taken.

Discussion

The risk-diagnosis and management approach, as described in this paper, has been developed in the empirical setting of a limited number of projects and enterprises. From systematic evaluations with the teams that worked with the RDM, it became clear that the RDM is so far perceived as being a valuable tool to detect the key risks in technologically complex product-innovation projects. Further application of the method and systematic evaluation of its effects will provide enriched knowledge about the capabilities of identifying and managing the risks in product-innovation projects.

The RDM method has been developed to be used in the product-creation process. From case studies using the RDM, we conclude that the method can be usefully applied in several stages in the product-creation process. However, the most powerful contribution is achieved at the end of the feasibility phase of the product-creation process. At this stage, the transition to the actual development and engineering of one particular product or product range takes place; uncertainty has to be managed, taking into account the potential risks relating to all the aspects of manufacturability, marketability, finance, human resources etc. The RDM has been specifically developed as a tool to facilitate the answering of the question 'can it be done?'.

A point of particular interest concerns the possible interdependencies between various risks. Owing to the analytical decomposition of the whole project in terms of its technological aspects (product, process, equipment, and production system) and organizational and commercial aspects, the RDM offers two ways of looking at interdependencies. First, the risks relating to the various technical aspects can be analysed in relation to each other. Second, the focus can be on the relationships between the technical, organizational and commercial risks.

Different methods of managing risks in product-innovation projects have been developed over the course of time. Some of these are the failure mode and effect analysis¹¹, the potential-problem analysis¹², and the fault-tree analysis and synthesis¹³. The RDM has been developed to provide an improvement over the existing risk methods:

- In most methods, a lot of time is spent in group sessions to identify the risks of a project. In group sessions, negative group effects are likely to occur. In a group, differences between the participants in terms of seniority and reputation can, not necessarily explicitly, severely disturb the free exchange of thoughts and ideas about what can go wrong in a project. In order to prevent these group effects in the RDM, the members of the risk team are individually interviewed to determine potential risk factors.
- In most methods, brainstorming techniques are used to identify risks. An advantage of brainstorming is that people stimulate each other. A disadvantage of brainstorming is that one is not sure whether all the possible risks have been considered. The RDM starts with a systematic description of the intended product, process, equipment and production system. This description stimulates interviewees to consider also technological details that at first sight seem to be of minor importance, and that would otherwise probably be ignored.

- In most methods, the identification of risks remains almost entirely restricted to technological aspects. The organizational and commercial risks of the project are underestimated.

A factor which should be considered with respect to the application of the RDM method relates to the amount of time required. Our experience is that, generally speaking, the application of the method in a project with a risk team of about ten persons demands from the project leader about 20 h, from the risk-team members 15 h, and from the project consultant who takes the lead in the process about 55 h. Before deciding to apply the RDM, it is recommended that it should be considered whether this time investment makes sense in relation to the complexity, innovativeness and importance of the project. Time dedicated to performing the RDM, however, forms part of the project-planning process, and it should be considered as an investment in the project that will pay off.

Meredith and Mantel¹⁴ have pointed to the fact that a lot of managers are risk avoiders, and that risk avoidance goes hand in hand with the avoidance of creativity. Seen from this angle, stressing the need to manage risks might reinforce existing risk-avoidance tendencies. The approach to risk management that we advocate should be understood *not* as a way of *avoiding* risks, but as a tool to support taking risks actively, and, most importantly, consciously.

References

- 1 Crawford, C M 'New product failure rates: a reprise' *Res. Manage.* Vol 30 No 4 (1987) pp 20–25
- 2 Booz-Allen and Hamilton *New Product Management for the 1980's* Booz-Allen & Hamilton, USA (1982)
- 3 Halman, J I M and Keizer, J A 'A risk management strategy for product innovation projects' in Geschka, H and Hübner, H *Innovation Strategies, Theoretical Approaches, Experiences, Improvements* Elsevier, Netherlands (1992)
- 4 Maidique, M and Zirger, B 'The new product learning cycle' in Burgelman, R A and Maidique, M A *Strategic Management of Technology and Innovation* Irwin (1988)
- 5 Van Engelen, J M L 'The practical usefulness of a new product selection model' *Pres. 9th Int. Conf. ISPIM* Eindhoven, Netherlands (5–8 Sep 1993)
- 6 Vliegen, H J W and Van Mal, H H 'Innovation and development strategy' *Int. J. Comput. Integr. Manuf.* Vol 4 No 3 (1989) pp 169–175
- 7 Cooper, R G and Kleinschmidt, E J 'New products: what separates winners from losers?' *J. Product Innovation Manage.* Vol 4 No 3 (1987) pp 169–184
- 8 Pinto, J K and Slevin, D P 'Critical success factors across the project life cycle' *Project Manage. J.* (Jun 1988) pp 68–75
- 9 Morris, P W G and Hough, G H *The Anatomy of Major Projects, A Study of the Reality of Project Management* John Wiley, UK (1987)
- 10 Turner, J R *The Handbook of Project Based Management, Improving the Processes for Achieving Strategic Objectives* McGraw-Hill, UK (1993)
- 11 Franke, W D *Fehlermöglichkeiten — Und Einflussanalyse in der Industriellen Praxis* Moderne Industrie, Germany (1987)
- 12 Kepner, C H and Tregoe, B B *The New Rational Manager* Princeton Research Press, USA (1981)
- 13 Bossche, A 'Fault tree analysis and synthesis' *Dissertation* University of Technology, Delft (1988)
- 14 Meredith, J R and Mantel, S J *Project Management, A Managerial Approach* John Wiley, USA (1989)

Joop Halman has an MSc in construction engineering from the University of Technology, Delft, Netherlands, and an MBA in business administration from the Erasmus University in Rotterdam, Netherlands. As a project manager, he has conducted both construction projects and reorganization projects. In 1989, he joined the Graduate School for Industrial Engineering and Management Science at Eindhoven University, Netherlands, as an associate professor in project management. He has conducted research projects in the field of product-innovation management.

Jimme A Keizer graduated as an organizational and industrial psychologist from the State University of Groningen in 1976. He worked as a management consultant in the field of nonprofit organizations. In 1988, he gained a PhD in human-resources management. In 1989, he joined the Graduate School for Industrial Engineering and Management Science of Eindhoven University, Netherlands, as an associate professor. He lectures on management consulting, and has conducted studies on risk analysis and learning strategies in product-innovation projects.