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R&D as % of Sales		1988	1989	1987	1988
1988	1989				
3.8	3.7	153	157	14	14
4.8	4.9	154	160	14	16
	6	112	116	13	18
			126	15	1

# CRITICAL SUCCESS FACTORS IN R&D PROJECTS

*Ten factors are critical to and predictive of success, but they come into play at different stages of the project's life cycle.*

Jeffrey K. Pinto and Dennis P. Slevin

Evaluating and accurately monitoring R&D projects across their life cycle is difficult. The project manager is constantly bombarded with a variety of information to consider and issues to resolve. Human conflicts, time pressures, and budgetary constraints can relegate the project manager to the role of a firefighter, spending his or her time extinguishing blazes before they get out of hand. While project managers are often the first to admit the need for better monitoring techniques throughout the life of their projects, surprisingly few tools exist for their use. As a result, many managers are continually forced to rely on rules of thumb, past historical data, and simplistic formulas in attempting to assess the periodic "health" of their projects.

A recent study was conducted to help project managers gain a clearer understanding of those factors which are critical to the successful implementation of R&D projects. The 159 R&D projects sampled include examples of new product development and introduction, computer software and hardware development, food, drug, and soft goods R&D, and equipment and appliance development (see editorial box, page 33)

The results of this study demonstrate the importance of ten critical factors. Further, the relative importance of these factors changes depending upon the stage in which the project currently resides. In other words, it is not accurate to view critical success factors as all being of equal and stable importance across the entire life of the project. Rather, the life cycle stage in which the project currently exists has important implications for determining which factors need to be given highest priority. As a result, this research is able to present clear guidelines to project managers who wish to do a better job of monitoring and assessing the current state of their projects but are uncertain of which factors are most critical to project success at different stages.

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## Critical Success Factors

A great deal of research has been conducted over the years in attempting to determine those factors which are most critical to project success (1,2,3 for example). Many writers have developed theoretical models and generated lists of factors which are felt to have an important impact on whether or not a research project will succeed. For example, it has long been accepted that top management support is necessary for gaining the necessary resources to adequately support a project through to completion. A recent study sought to derive a set of critical success factors which not only make conceptual sense, but which can be supported empirically across a wide range of both research and non-R&D projects (2). This study resulted in the development of both a 10-factor model of the project implementation process and an instrument, the Project Implementation Profile, which project managers can use to periodically monitor the current state of each of the ten factors throughout a project's life. These ten factors represent those items or activities found to be critical to project implementation success. The factors are:

- **Project Mission.** Initial clarity of goals and general directions.
- **Top Management Support.** Willingness of top management to provide the necessary resources and authority/power for project success.
- **Project Schedule/Plans.** A detailed specification of the individual action steps required for project implementation.
- **Client Consultation.** Communication, consultation, and active listening to all impacted parties.
- **Personnel.** Recruitment, selection, and training of the necessary personnel for the project team.
- **Technical Tasks.** Availability of the required technology and expertise to accomplish the specific technical action steps.
- **Client Acceptance.** The act of "selling" the final project to its ultimate intended users.
- **Monitoring and Feedback.** Timely provision of comprehensive control information at each stage in the implementation process.
- **Communication.** The provision of an appropriate network and necessary data to all key actors in the project implementation.
- **Trouble-Shooting.** Ability to handle unexpected crises and deviations from plan.

In addition to these ten critical factors, all of which are to some degree within the control of the project team, four additional factors were included in this research. These critical factors may be thought of as important variables which are often beyond the control of the project team, yet which can have a powerful impact on either the success or failure of the intended project. These exogenous factors can be defined as:

- *Characteristics of the Project Team Leader.* Competence of the project leader (administratively, interpersonally, and technically) and the amount of authority available to perform his or her duties.
- *Power and Politics.* The degree of political activity within the organization and perception that the project furthers an organization member's self interests.
- *Environmental Events.* The likelihood of external organizational or environmental factors affecting the operations of the project team, either positively or negatively.
- *Urgency.* The perception of the importance of the project or the need to implement the project as soon as possible.

### Project Life Cycles

The concept of project life cycles is well accepted in the field of project management. While many different examples of project life cycles exist, with a variety of numbers of distinct stages, for this research we have employed a four-stage life cycle: Conceptual, Planning, Execution, and Termination.

*Stage I*—The conceptual stage involves the initial

***Project mission is the most important factor related to project success across all four stages of the project life cycle.***

determination of a need for a project. Preliminary goals and alternatives are specified as well as the possible means of accomplishing the goals.

*Stage II*—Once goals have been agreed upon, a more formal set of plans are developed in order to accomplish these goals. These activities often involve the definition and allocation of specific tasks and resources.

*Stage III*—The actual "work" of the project is performed during the execution stage. Materials or resources are procured, the system or project is produced, and performance capabilities are verified.

*Stage IV*—Once the project is completed, several final activities must be performed, including the release of resources and transfer of the project to the clients, as well as the reassignment of project personnel. There is often some form of project review and evaluation to assess relative successes and failures, their likely causes, and possible corrective actions in case they occur again.

### Study Results

The results of the latest study support the contention that the relative importance of the critical success factors change with the stage of the project life cycle. Table 1 lists—in order of importance—the factors that were found to be truly critical to project success at each stage of the project. In the Conceptual stage, the Project Mission, Client Consultation, Personnel, and Urgency account for over 92 percent of the variance in project success at this earliest stage. In the Planning stage, Project Mission, Environmental Events, Schedule, Monitoring and Feedback, and Client Acceptance had an r-square value explaining 63 percent of the variance in project success. For the Execution phase, Mission, Technical Tasks, and Top Management Support were able to predict 54 percent of project success. Finally, in the Termination stage, Mission, Schedule, Client Acceptance, Technical Tasks, and Personnel had an r-square value accounting for 72 percent of the variance in project success.

### What the Findings Imply

1. *Be Aware of the Project Mission.*—In one sense, this implication seems obvious, yet it needs to be stressed. Project Mission is *the* most important factor related to project success across all four stages of the project life cycle. This result suggests that if the Project Mission is

**Table 1—Critical Success Factors at Each Project Stage, In Order of Importance**

- 
- Stage 1: Conceptual**
    - Project Mission
    - Client Consultation
    - Personnel
    - Urgency
  - Stage 2: Planning**
    - Project Mission
    - Environmental Effects
    - Schedule
    - Monitoring and Feedback
    - Client Acceptance
  - Stage 3: Execution**
    - Project Mission
    - Technical Tasks
    - Top Management Support
  - Stage 4: Termination**
    - Project Mission
    - Schedule
    - Client Acceptance
    - Technical Tasks
    - Personnel
-

## How the Study Was Conducted

A questionnaire was mailed to 585 members of the Project Management Institute (PMI), yielding a total sample of 409 projects, of which 159 of the responses could be classified as R&D projects. The final sample of projects included examples from *Fortune* 500 firms as well as smaller companies across the United States. In terms of actual R&D project cost, examples ranged from a small, \$5,000 pilot study to a \$2.5 billion government funded research grant.

Typical examples of projects and industries sampled include new drug R&D at several large pharmaceutical companies, chemical and petrochemical process research through four major, U.S.-based oil companies, aerodynamic engineering research at three of the largest U.S. aircraft manufacturing firms, government-sponsored nuclear research, computer software and hardware development at several of the largest computer companies.

The Project Implementation Profile (PIP) was used to identify the 14 critical success factors and factor scores over the project life cycle (4). The PIP requires participants to indicate their level of agreement to a series of 72 questions covering the 10 critical success factors and the 4 additional

external factors related to project implementation success. Each of the ten critical success factors is composed of 5 sub-items. Of the external factors, Power and Politics and Urgency are each composed of 5 sub-items. Environmental Events and Characteristics of the Project Team Leader both have 6 sub-items.

The PIP's measure of project success is an average of 13 items, including level of adherence to budget and tentative time schedules, project performance capabilities, user acceptance and usage of the project, and user benefits from the project. The success measure had to be multi-dimensional in order to address the diversity of concerns that go into any assessment of the success of an R&D project.

The questionnaire required participants to think of a project in which they were currently involved or had recently completed. This project was to remain their frame of reference while completing the questionnaire. The four-stage project life cycle previously discussed was used to identify the stage of each project. Brief descriptions of the stages were presented to allow each respondent to answer the questionnaire with both a specific project and a specific life cycle stage in mind.

Stepwise regression analysis was used to identify the most important critical success factors at each stage of the project life cycle. Table 2 shows the relationship of the key factors to project success.

*Table 2—Key Factors for Each Stage of the Project Life Cycle and Their Relationship With Project Success*

Stage of Project Life Cycle	Number of Projects	Factors	Cumulative R-Square	Relationship with Project Success
Conceptual	19	Mission	.67	Positive
		Client	.81	Positive
		Consultation		
		Personnel	.87	Positive
Planning	30	Urgency	.92	Positive
		Mission	.30	Positive
		Environmental	.38	Negative
		Events		
		Schedule	.50	Positive
Execution	81	Monitoring and Feedback	.54	Positive
		Client	.63	Positive
		Acceptance		
		Mission	.46	Positive
Termination	29	Technical	.51	Positive
		Tasks		
		Top Management	.54	Positive
		Support		
		Mission	.42	Positive
		Schedule	.48	Positive
		Client	.56	Positive
		Acceptance		
		Technical	.61	Positive
		Tasks		
		Personnel	.72	Negative

forgotten, or becomes increasingly unclear over the life of the project, chances are great that the project will fail. There are many examples of R&D projects that, for whatever reasons, underwent such metamorphoses or got off on such tangents that the originally-agreed-upon project goals and purposes became meaningless. Obviously, some modification and change is expected during the life of any R&D project. The point that must be stressed, however, is that the underlying purpose of the project must remain clear and important for all members of the project team (4).

**2. Consult with Clients Early.**—In R&D, “clients” may refer either to an in-house functional area that will make use of the completed project (e.g., manufacturing), an in-house unit that will be in charge of the commercialization effort (marketing), or customers outside the organization. Regardless of which group is the client for a particular project, it should be apparent that consultation and communication with clients across the development of the project is very important for its successful implementation. Further, it should not be surprising that Client Consultation must necessarily occur during the early conceptual stage. In the R&D arena, the Project Mission is often shaped as a direct result of Client Consultation.

**3. Stay “Well Connected” to Clients.**—Client Acceptance, a “selling” activity, is necessary during both the Planning and final Termination stages. Apparently, the sequence of operations concerned with the client follows the pattern of: 1) Consult to determine specific needs, 2) Sell our ideas, budgets, time frame to completion, and 3) Perform a final verification of client acceptance once the project has been completed. This verification is often in the form of a formal presentation of the project results to the intended users.

**4. A Sense of Urgency About the Project Helps.**—It seems obvious that projects which are viewed as “important” do better than projects which are seen as routine. This point needs to be emphasized, however, because it has important implications for the ultimate success or failure of R&D projects. The importance of the Urgency factor is demonstrated during the earliest project life cycle stage. It is important for project managers to attempt to instill a sense of urgency, or importance, regarding the project to three parties: project team members, significant members of the parent organization who control needed resources, and any identified clients for whom the project is ultimately intended. “Urgent” projects have a much greater ability to collect needed resources and additional funding, when needed, than projects which are viewed as routine, dull, or even unnecessary.

**5. Make Sure We Have the Technology to Succeed.**—The success of R&D projects often depends on the organization possessing the appropriate technology to facilitate their successful implementation. Not only is it important that the project team have the necessary technical means to succeed, but the vital stages for this factor are in the project’s Execution and Termination. It is during the actual work of the project that the

importance of adequate technology comes into play most powerfully.

**6. Set Up and Maintain a Scheduling System.**—Because so many research and/or development projects are nonroutine and involve considerable complexity, uncertainty and need for innovativeness, there simply are no guarantees as to when certain project milestones will be met. As many R&D project managers have put it, “You can’t regulate creativity!” Nevertheless, as the results of this study point out, setting up a system for tentative scheduling is of great importance to successful R&D projects. Further and not surprisingly, the most important stages in which to address project schedules are during the Planning stage, when preliminary milestones are developed, and at project Termination. Scheduling during the project’s Termination usually serves a two-fold purpose. First, schedules provide feedback as to how well the project team accomplished its goals. Second, schedules are needed for the transfer of the developed project to its intended users, either within the organization or outside. Transferring the project and getting it on-line usually require an additional series of target dates and schedules.

**7. Put the Right People on the Project Team.**—The results of our study demonstrate the importance of recruiting, selecting and training people who possess the necessary technical and administrative skills to positively influence the ultimate success of the project. As Table 2 shows, this factor becomes most critical to project success during the early Conceptualization and the final Termination stages. In the Conceptualization stage, the relationship between Personnel and Project Success is positive, as one would expect. During this first stage, one of the important questions which must be answered is whether or not the organization possesses the necessary personnel to successfully implement the project. If not, the project should be put on hold.

Conversely, during the Termination phase, the relationship between project success and Personnel is negative. Not surprisingly, as the project is developed and commercialized, the personnel responsible for its successful implementation are reassigned to other duties.

**8. As Much as Possible, Protect Your R&D Team.**—No matter how well a project manager may run his or her project, there are no guarantees of success. We exist in a turbulent world where what seemed a good idea today may be obsolete next week. There is little the R&D project manager can do about this beyond accepting it and dealing with it as intelligently and warily as possible. One element of this environment which the project manager may exercise some control over, however, is the make-up of the project team. As “environment” is defined in this study, it not only refers to that which is external to the organization, but to anything that is external to and can impact on the project team itself. As a result, Environmental Effects also includes such phenomena as turnover within the project team, budget cuts in the midst of the development process, departmental reorganizations, and so forth.

Not only were Environmental Effects found to have a

***Project managers who cast a blind eye on potential hazards often doom their projects to failure in their enthusiasm to get started.***

significant negative impact on project success, but this factor must be addressed during the Planning phase. It is during the Planning stage when budgets are developed, schedules are set, and specific tasks are allocated. Consequently, it is vital to conduct an honest assessment at this time as to whether there is a likelihood of any of the aforementioned environmental actions impacting on the project at some point in the future. Project managers who cast a blind eye on potential hazards are often dooming their projects to failure in their enthusiasm to get started.

**9. Make Sure Top Management Gets Behind the Project.**—It is well-accepted that top management can either help or hinder a project. Top management grants necessary authority to the project manager, controls needed resources, and rewards the final results. Its role in the successful implementation of projects should not be overlooked. Top management support is most necessary for project success during the Execution stage. When the actual work of the project is being performed, it is important that top management make its presence known by providing the necessary money, manpower, and raw materials for the project as they are needed. Further, project managers need to know that top management will support them in the event of unforeseen difficulties or crises.

## **In Conclusion**

That ten factors have been found critical to and predictive of R&D project success tells only half the story. It is also necessary to know when in a project's development these factors come into play. In the modern organization, the manager of R&D projects assumes a duty characterized by high stress, frenetic activity, role overload, and the need to wear a variety of hats: administrator, technical expert, dreamer, cheerleader, and facilitator. The Project Implementation Profile (PIP) has had great success in helping the project manager to more accurately monitor and evaluate the on-going status of R&D projects. (5) The results reported in this article suggest some guidelines for project managers to employ in more efficiently assigning their personnel and specific project duties. Because we can suggest the set of factors that are most critical for project success and the specific stages at which they need to be considered, project managers are in a position to better sort out and prioritize the variety of demands for their time and resources, making more informed estimates concerning the current status and likely success of their projects. ④

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