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The Fuzzy Front End - Development and Testing a Methodology for Projects Kick off through Simulation Based Planning

הערה: אין במחקר זה כל פוטנציאל מסחרי

Planning of the Fuzzy Front End of Projects

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1. Abstract

The initial stages of New Product Development (NPD) projects are known as the "Fuzzy Front End" (FFE); this is the messy "getting started" period. It is in the front end where the organization formulates a concept of the product to be developed and decides whether or not to invest resources in further development of an idea. The FFE begins with the initial search for new opportunities, through the formation of a germ of an idea to the development of a precise concept. The FFE ends when an organization approves and begins formal development of the concept.

Traditionally, the decisions early on in the project life cycle are based on documents and presentations with little or no model-based analysis. We present a new approach for the FFE of the new product development. This approach combines a workshop and a decision-making process in which the design of a new product is considered. The workshop and the innovative decision support system were used to obtain immediate feedback regarding the effectiveness of various tradespace alternatives. Of these – a single design alternative is chosen for the project execution.

2. Introduction and the project fuzzy front end

Innovation is a process that encompasses the course of events from the early stages of the product inception—with a lot of fuzzy ideas—to the final market launching stage of the new product. We distinguish between three phases of the innovation process (Koen, P. et al., 2001):

1) Front end,

2) New product development (NPD) process, and

3) Commercialization.

Only a minute fraction of innovative ideas materialize into new product development. During the preliminary stages, the innovative ideas are funneled; of 3000 ideas generated, only 14 new product development projects are launched and of these, only a single project will survive up to the stage of commercialization (Stevens, G. A. & Burkley, J., 1997). The funnel model was suggested to emphasize the selection among different alternatives during the innovation process reaching one coherent choice at the end of the funnel (Steven C. & Kim B. Clark, 1992).

An inverse relationship exists between the level of uncertainty in the innovation process and the level of knowledge and information aggregated. As the process progresses the uncertainty level decreases while the amassed information (e.g., reports, design documents, schematics, etc.) increases. During the front end phase the uncertainty level is very high whereas the available information is very low. Therefore, efficient handling of the front end stage is of crucial importance (Koen, P. et al., 2001).

In the innovation management literature, several terms are used to describe the front end of new product development, e.g., “pre-development” (Cooper & Kleinschmidt 1994), “fuzzy front end” or “pre-phase 0” (Khurana & Rosenthal 1997/1998).

The fuzzy front end occurs while:

a) Discovering the project scope based on stakeholders' needs and expectations;

b) Defining the specifications to be designed such that they satisfy the requirements.

Consequently, the Fuzzy Front End stage is one of the most significant drivers of project success, and is the phase with the highest potential for optimization (Koen, P. A., et al., 2002). Well-defined projects cost less, take less time to execute, and operate better (Cooper 2011).

The FFE presents many challenges. Stakeholders' requirements need to be understood and formulated. In large systems it may often be impractical to model entire systems due to their sheer size and complexity. The alternatives are often manual, resulting in missed alternatives that may have been the best choice. Our challenge is to improve the way alternatives are discussed and selected.

3. Multi-attribute tradespace exploration

A "design variable" is a designer-controlled quantitative parameter that reflects an aspect of a design concept—typically, representing some physical aspects of a design. The “tradespace” is a mathematical vector space. Each point in this space represents a "design vector" comprising an enumerated set of design variables that, taken together, uniquely define a design or architecture. The vector provides a concise representation of a single architecture, or design. The entire tradespace spans the complete space of all potential design solutions. The expansion of this tradespace is the essence of innovation—a creative recombination to create a new system that never before existed.

Each point in the tradespace is associated with a dimensionless numerical value called the "value" or "benefit", which is a metric that captures the goodness of something to the stakeholders. Benefit metrics are specified by someone with knowledge of the need and/or use of the system, typically varying from zero (minimal acceptable) to one (most desirable). The term “tradespace” was coined as a combination of the words “trade-off” and “playspace”, where “trade-off” indicates the method of traversing the tradespace in search of the optimal boundary surface in the metric space termed the “efficient frontier”. Optimality, in this context, is defined with respect to the value or the benefit. Movement along the frontier requires trading off one design variable (e.g., “risk”) with another (e.g., “performance”).

"Multi-attribute tradespace exploration" is the benefit-guided search for better solutions within the tradespace. This approach manifests the means for investigating a multitude of design options, thus deriving information that will become the basis for decision making.

4. Research questions and hypotheses

This section provides an overview of the experimental design, starting with research questions, the hypotheses and culminating in the "Experiment Results" where we report on the results of the experiment.

Due to the importance and critical impact of the Fuzzy Front End stage of the project, we examine the following questions:

Q1: *Does Simulation-Based Planning improve the FEL process?*

Q2: *Does the FEL process using Simulation-Based Planning increase the confidence level of the project duration?*

Q3: *Does Simulation-Based Planning assist in developing a better understanding regarding the project goals and alternatives?*

This study focuses on the contribution of Simulation-Based Planning (SBP) at the Fuzzy Front End Stage of a project to: choosing an alternative, risk management, and work planning.

Specifically, the following hypotheses were tested in controlled workshops and field studies:

H1: *Simulation-Based Planning assists in developing a plan for reducing the project risks*.

H2: *Simulation-Based Planning assists in determining the LCC costs of the project and the schedule forecasting.*

H3: *It is possible to create a shared understanding among project team members by using Simulation-Based Planning*.

5. Research workshop

A workshop was designed to test the impact of Simulation-Based Planning on the FEL process. The workshop was performed for each project participating in the research.

The participants in the workshops were asked to fill out questionnaires.

6. Implementation in industry

The workshop was implemented in four different beta sites: nine workshops were performed on nine individual projects, where the total financial value of the projects exceeded $200M.

The sample included 102 participants, comprising 13 female and 89 male participants.
Each participant took part in one workshop. Group sizes were 7–17 participants;
84% of the participants were experienced engineers.
The age average was 44.3 and the average years of experience was 14.9.
Less experienced engineers highly evaluated the contribution of the workshop to their commitment to the project. (Nonparametric correlation, Spearman's rho, -0.3814.)
Participants expressed satisfaction from the contribution of the workshop.

Statistical tests accentuates the contribution of the workshop in the following aspects:

- Development of a plan for reducing the project risk.
- Achieving a frozen detailed plan.
- Development of a better understanding regarding project goals and alternatives.
- Reaching consensus amongst team members regarding the project plan.

7. Earned Value Analysis

Earned value management (EVM) is a technique for measuring project performance and progress. It has the ability to combine measurements of the project management triangle: scope, time and costs.

Essential features of EVM implementation include:

1. A project plan that identifies the work to be accomplished. The project is broken down into activities of relatively short duration.
2. Project schedule baseline plan: the original project plan.

3. A valuation of planned work, called Planned Value (**PV**), which is measured units of currency (e.g., dollars or Euros) or in labor hours.
4. Pre-defined "earning rules" (also called metrics, e.g., 0/100 - no credit is earned for an element of work until it is finished, 50/100, etc.) used to quantify the percentage of completion of work, called Earned Value (**EV**).
5. The final step is to measure the project progress during its execution. When activities are started or completed, EV is accumulated. This is typically done at regular intervals (e.g., weekly or monthly). However, EV can also be accumulated in near real-time, when work elements are started/completed. In fact, waiting to update EV only once per month (simply because that is when cost data are available) only detracts from a primary benefit of using EVM, which is to create a technical performance scoreboard for the project team.
6. Calculation of:
   - Project schedule overrun: defined as PV/Baseline Plan.
   - CPI (Cost performance index) when CPI = (EV/AC). CPI greater than 1 is good/favourable (meaning that the project is under budget):

     - < 1 means that the cost of completing the work is higher than planned (bad);
     - = 1 means that the cost of completing the work is right on plan (good);
     - > 1 means that the cost of completing the work is less than planned (good);

After completing the FEL workshop and determining a chosen design alternative and work plan, we accumulated EVM data of the projects in order to monitor cost variance and schedule overrun. EVM data were gathered periodically each quarter during a period of four to five quarters.

Error! Reference source not found.1 presents the accumulated data of all six 'R' company projects. The table shows that the T.N. (time now) CPI value is 0.90 and the

Schedule Overrun is 1.27 which means that on average the projects have overrun their original baseline plan by 27%.

Table 1: the accumulated data of all six 'R' company projects

	Q4/14	Q1/15	Q2/15	Q3/15	Q4/15	Q1/16	Q2/16	Q3/16	Q4/16	Q1/17	Q2/17	Q3/17	Q4/17	Q1/18
Baseline	207826	270765	292727	304856	343043	389569	461839	526553	545411	579872	592339	610414	626622	639589
PV	174267	285428	368256	400407	433092	494217	586658	623920	644171	665813	678217	689779	700323	701910
AC	182212	253416	334835	413982	454309	504401								
EV	174270	254488	293237	368327	407307	454047								
CPI	0.96	1.00	0.88	0.89	0.90	0.90								
PV/Baseline	0.838524	1.054154	1.258019	1.31343	1.262501	1.268625	1.270265	1.184914	1.181074	1.148207	1.144981	1.130018	1.117616	1.097439

These values should be compared with the average 'R' company CPI and Schedule Overrun values, which are known to be CPI=0.83 and Schedule Overrun = 33%.

The project population on which the FEL workshop was implemented exhibited a significantly better performance than an average project in company 'R' in terms of Schedule Overrun and cost variance; in particular, the schedule variance is 5% better and the cost variance is 7% better.

8. Summary and conclusion

The FFE stage is one of the most significant drivers of project success. Projects which are well-defined from the very beginning cost less, take less time to execute, and operate better (Cooper 2011).

We presented a new approach based on a workshop and tools that provide an enhancement of the decision-making process when the design of a new product is considered. The workshop is based on an innovative decision support system used to obtain immediate feedback regarding the effectiveness of various tradespace alternatives. The tools are used by the workshop participants for simulation-based planning of the master Gantt of the project which synchronizes the various disciplines and establishes their commitment to meet the major milestones of the chosen alternative for the project execution. The simulation tool employed for simulation-based planning enables the exploration of the existing tradespace of the project execution while promoting decision making which is critical at this fuzzy stage as related to the risk level of the project.

In addition to these tangible outcomes, the workshop also offers more qualitative advantages. During the workshop the situation is created that all the discipline leaders as well as other stakeholders are assembled in a joint location. This results in the opportunity for quick online communication and immediate feedback, sharing and cross pollination of ideas between the participants, all of which encourage the build-up of relationships and team spirit and facilitate reaching a consensus amongst the team members. Consensus does not mean that everyone always agrees, but it does mean that everyone agrees to implement a decision because they believe that their reservations were heard and considered and that the decision is the best one possible under the circumstances.

Most importantly, a shared understanding is developed as the whole project team is exposed to the whole project and every team member can learn the tasks and concerns of all other team members.

The workshop was successfully implemented on a variety of projects in the industry with an overall budgetary scope exceeding $200M. All the projects which participated in the study exhibited an improvement in the success criteria. Participants expressed satisfaction from the contribution of the workshop. Moreover, continuous monitoring of the projects for over a year after executing the FEL workshop shows significantly better performance of these projects in terms of cost and schedule variance as compared with the average performance within the company.

The results obtained in our study show that the investment of time and resources in conducting the workshop at these early stages of the project contributes significantly to the robustness of the project work plan and boosts the development of a shared understanding amongst team members and other stakeholders.

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