Critical Success Factors in R&D Project Management in Military Systems Acquisition and a Suggested R&D Project Selection Methodology for Turkish Armed Forces

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Abstract- Turkish Armed Forces have developed a military systems acquisition strategy based on local R&D work. The first objective of this study is to determine critical success factors in R&D project management in the military system acquisition in Turkish Armed Forces (TAF) as seen from the perspectives of different stakeholders of the national defense industry.

In order to accomplish this, surveys were applied to R&D project manager/members from Ministry of National Defense Undersecretaries for Defense Industries and project officers from TAF, defense industry firms that do business with TAF, and military officers who are selected for graduate education at Yeditepe University system engineering faculty.

The second objective is to propose an R&D project selection methodology to determine whether there are Army technologies suitable for collaboration with industry. The proposed methodology is applied to laser technology.

This paper is the first paper to report on the decision models of various stakeholders on project success factors and project selection criteria in the Turkish defense industry.

Key words: R&D Project Management, Critical Success Factors, R&D Project Selection, Army Industry collaboration, Goal Directed Project Management, Turkish Armed Forces; AHP

I. INTRODUCTION

Research and technology development has become one of the essential driving forces for corporate growth and national development. On the other hand one of the most difficult tasks in any organization is the management of R&D activities. With increasing complexities of today's projects and their business environments, companies have moved toward more sophisticated tools and techniques for effectively managing their multidisciplinary activities.

Almost all of today's executives are in agreement that the solution to the majority of corporate problems involves obtaining better control and use of existing corporate resources. Emphasis is being placed on looking internally and externally for the solution to those problems. As part of the attempt to achieve on internal and external solution, executives are taking a hard look at the ways corporate activities are being managed. System thinking and project management are techniques now under consideration (Kerzner, 1984).

The literature discussing success in R&D project management is vast. Several authors [3-6, 9, 12, 15, 16, 20, 24, 33, 35, 39, 47, 48, 51]♣, writing on project management, have developed sets of critical success factors. The studies show that there are large numbers of factor influencing the success of a new product or an R&D project. Some of them are controllable within the organization, but others are external and uncontrollable. We have tried to examine these papers to find whether a general agreement exist about the factors leading to success or failure R&D projects. In these studies, the authors use variety of techniques to derive the significant factors.

Project selection is another important issue in R&D management. Numerous studies exist proposing both quantitative and qualitative approaches to selection problems.

This paper has two main goals. The first goal is to determine the decision models of various stakeholders in defense industry in Turkey on critical success factors in project management. The second goal is the application of a selected approach to R&D project selection within the R&D-based military systems acquisition in Turkey.

II. LITERATURE REVIEW

A. Factors Affecting Project Success

The importance of critical success factors in management first gained widespread attention following publication of an article by Rockart [50]. It showed the need among top executives for certain critical elements of information, not provided by the management information systems or the data analysis systems available.

The initial Rockart paper was closely followed by the publication of a methodology for critical success factor identification developed by Bullen and Rockart [8]. The research conducted since then has been done either through the interview process as described by Bullen and Rockart, or by the questionnaire method. [16].

Pinto and Prescott [47] hypothesized a set of critical success factors, and then conducted a validation study based on empirical evidence. The objective was to identify a set of critical success factors for each life cycle phase that were general rather than company- or industry-specific, and to determine the relative importance of the critical success factors across life cycle phases.

♣ Reference Number

TABLE 1: CRITICAL SUCCESS FACTORS IN THE PROJECT LIFE CYCLE (PINTO & PRECCOTT, 1988)

PHASE	CSF
Concept	- Project Mission - Client Consultation
Planning	- Project Mission - Top Management Support - Client Acceptance
Execution	- Project Mission - Troubleshooting - Well-defined Schedule or Plan - Technical Tasks - Client Consultation
Termination	- Project Mission - Technical Tasks - Client Consultation

Conclusions from the studies are nonuniform, and in same cases, they are even contradictory. To study this issue in greater depth, Balachandra and Friar [5] undertook a review of the literature of R&D project management and new product development. After examining over 60 papers in this field, to better understanding of phenomenon, they categorized the large number of factors that determine success. The level of contradiction among the factors affecting the success of new product development projects is interesting (Table 2).

TABLE 2: CONTRADICTORY RESULTS OF MAJOR STUDIES (BALACHANDRA AND FRIAR, 1987)

FACTOR	POSITIVE EFFECT # of studies	NEGATIVE EEFECT # of studies
Market Related		
Potential Market/Existing Market	3	5
Market Analysis	4	7
High Growth	5	1
Early to market	2	3
Rate of product introduction	2	4
Technology Related		
Innovative Product	4	4
Perceived Value	5	1
Patentability	4	3
Demand Pull/Technology Push	4	1
Environment Related		
Important/Not Important	4	1
Organization Related		
Support from Marketing	6	3
Use of Quantitative Techniques	1	2
Source of Ideas from Marketing	3	3

Pinto and Slevin [48] describe a process used to determine critical success factors that are felt to be predictive of successful project management in their studies. Ten factors were discovered that relate well to previous theoretical formulation in the literature. In addition, these ten factors have been linked in an interdependent quasi-sequential framework. They claim that this research has provided the basis for developing a behavioral instrument to be used as a diagnostic for assessing the status of any project as determined by ten-factor model.

Pinto and Slevin [48] state that an empirically based model of the project implementation process, as well as an instrument to measure the status of a project implementation is seams to be needed. Such a model might be described as follows:

$$\mathbf{S} = f(\mathbf{X1}, \mathbf{X_2}, \mathbf{X_3}, \mathbf{X_n})$$

S Project Success, and

X_i Critical Success Factors

But this kind of study only attempts to identify the critical success factors, but does not measure the strength of their relationship with project success. They performed a study at the University of Pittsburgh using MBA students. All sample subjects were employed on full-time basis, predominantly with locally based fortune 1000 companies. All had been a member of a project team in their respective organizations within the last two years.

Using Analytical Hierarchical Model they generated a set of critical success factors list and some interrelationship among critical factors. As Figure 1 shows, a process framework of project implementation has been developed for heuristic purposes, based on ten factors discovered in their analysis.

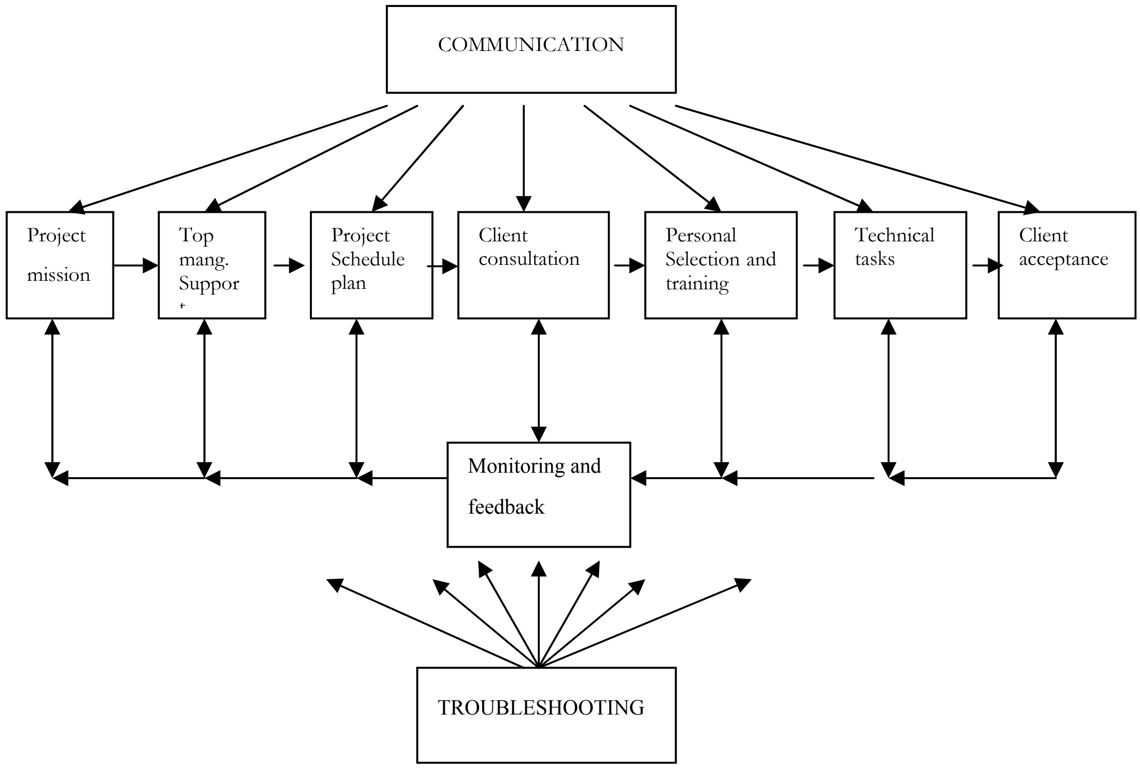

Fig. 1: Ten Key Factors of the Project Implementation[1]

The factors appear to be both time sequenced and interdependent. According to Pinto & Slevin's framework, it is important first to set the goals or define the mission and benefits of the project before seeking top management support. In addition to the set of seven factors along the "critical path," ranging from *Project mission* to *Client acceptance*, other factors such as *Communication* and *Monitoring* and *Feedback* are hypothesized to necessarily occur simultaneously and in harmony with other sequential factors. The "arrows" in the flow chart represent information flows and sequences, not necessarily causal or correctional relationship.

They state that the resulting model would suggest a potentially empirically grounded basis for determining critical success factors for project implementation, rather then relying on past research, which has remained predominantly conceptual. For the project manager, such a tool would be a valuable aid in assisting him/her assuring the likelihood of project implementation success through providing a series of prescriptive action to be taken at critical points in the project.

The result of the Pinto and Slevin study and this approach was used by Çimen [10] for determining the critical success factors of projects managed in manufacturing, transportation, and mining/energy sectors by public agencies in Turkey by means of a survey.

Typically, all of the studies have several things in common:

1. They identify a number of factors, based on literature or on common sense, those have been surmised to have influence on the success of projects.
2. They select a sample of projects and evaluate the factors for these projects and they perform statistical analysis to identify the significant factors.
3. Some studies collect data from actual project.
4. Some of them ask executives to rate the contribution and importance of factors for the success of projects of which the executives have some personal understanding.

After making background literature investigation, we came to conclusion that that several authors, writing on project management, have developed sets of critical factors which, if addressed, will significantly improve project management implementation chances. In these studies the authors use variety of techniques to derive the significant factors.

However there are arguable points in these studies:

[1] Pinto and Slevin [48]

1. In many cases project management prescription and process frameworks are theoretically based, rather than empirically proven.
2. Evidence supporting these sets of factors is often anecdotal, single-case study, or theory-derived, rather than empirical.
3. There is relatively little empirical basis for the resulting models and theories of project management and implementation.

It would be useful to have a more generic framework of critical success factors that is both compatible with literature and is empirically supported. After classifying these factors in three dimensions, ***people, system, and organization***, we conducted surveys in order to evaluate these factors from the point of view of people, who are related to acquisition process of TAF, project manager/members from Ministry of National Defense Undersecretariat for Defense Industries and TAF, and firms from the defense industry.

B. Project Selection Approaches

The R&D project-selection is a critical area of organizations. Because project selection is the means by which technology strategies are actually implemented, the long-term success of a company/organization is often determined by the effectiveness of its project-selection process [54]. The literature on R&D project selection is vast. There are as many approaches as there are different researchers in the field. [2, 11, 13, 14, 17 – 19, 21, 27, 28, 31, 32, 34, 36 – 38, 40 – 43, 52, 57, 59, 61]

Cook and Seiford [13] discuss R&D project selection in government ministries in USA. They emphasize its multidimensional and, therefore, multiobjective nature of project selection. The quantitative dimensions are reported to be:

1. expected future savings in capital, user, operational and maintenance costs,
2. economic impact in terms of profits and productivity in the private sector, job creation,
3. scale of the problem in terms of government investment.

Qualitative dimensions include:

1. political and senior management suuport,
2. client support,
3. public support,
4. environmental impact,
5. technical and educational relevance,
6. degree to which project interfaces with other ongoing projects,
7. impact on ministry profile,
8. impact on national profile.

In addition to the above-mentioned dimensions, they also report two other aspects which must ultimately have an almost overriding impact on the selection criteria:

1. likelihood of success of the research
2. likelihood of implementation of the results.

Costello [14] suggests that the middle management should prepare to evaluate R&D proposals after obtaining general guidance on R&D priorities from top management:

1. market analysis: to determine the market potential associated with successful commercial develepment of the R&D idea.
2. cost analysis: to determine the firm’s capabilities of reaching the commercial introduction stage in a competitive cost position.
3. competitive analysis: to assess the firm’s position relative to competitors and the likelihood of securing and maintaining economic value from the idea.
4. uncertainty analysis: to assess the relative risk of successfullu obtaining economic value from the R&D idea compared with competing ideas.
5. scientific merit: to determine the likelihood of R&D success and its contribution to the quality of the R&D environment in the firm.

The government laboratory reported by Costello [14] chose to use the following criteria in selecting among the suggested R&D projects:

1. Category 1: Staff Capability.
2. Category 2: Research Needs.
3. Category 3: Contribution to the Laboratory’s Stature
4. Category 4: Government Interest.

Henriksen and Traynor [23] placed the R&D selecting methods into one of the following categories:

1. Unstructured peer review;
2. Scoring;
3. Mathematical programming, including integer programming (IP), linear programming (LP), nonlinear programming (NLP), goal programming (GP), and dynamic programming (DP);
4. Economic models, such as internal rate of return (IRR), net present value (NPV), return on investment (ROI), cost-benefit analysis, and option pricing theory;
5. Decision analysis, including multi-attribute utility theory (MAUT), decision trees, risk analysis, and the analytic hierarchical process (AHP);
6. Interactive methods, such as Delphi, Q-sort, behavioral decision aids (BDA), and decentralized hierarchical modeling (DHM);
7. Artificial intelligence (AI), including expert systems and fuzzy sets;
8. Portfolio optimization.

Any logical combination of these techniques can be used to construct an organization’s “optimal” R&D portfolio.

C. A New Methodology for Collaboration Assessment

For TAF one of the most common ways to reduce R&D costs is to form partnerships with other firms to carry on joint R&D activities. In doing this, sharing of the **cost, information** and **capabilities** among the partner firms is achieved.

To determine whether there are Army technologies suitable for collaboration with industry, we used the approach, developed by Wong [65], involving a ***two-dimensional framework*** portioned into four ***management domains***.

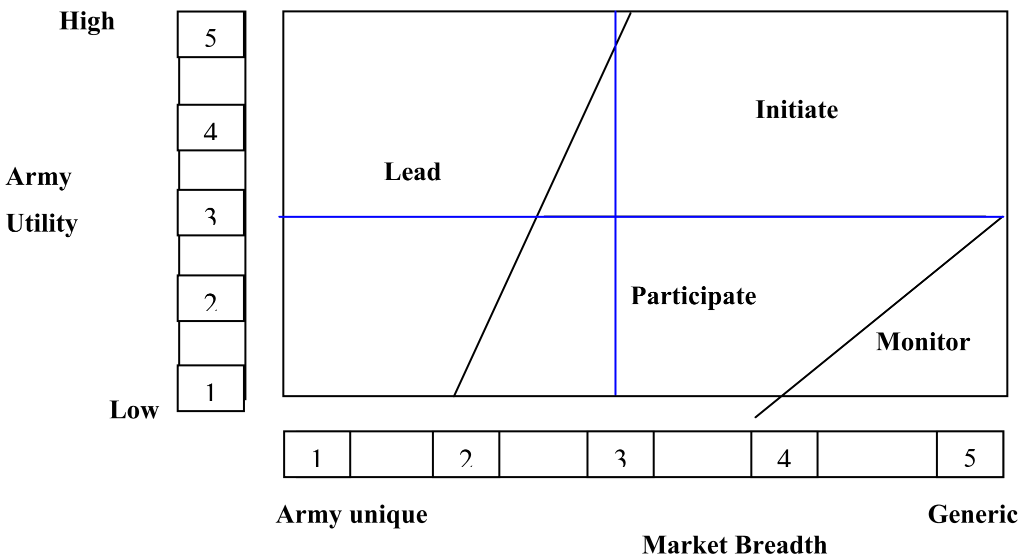

Figure 2: Collaboration Assessment Framework and Management Domains [65]

Army Utility reflects a technology's potential contribution to helping the Army accomplish its mission. In the framework Army utility is represented as a continues scale that ranges from ***low*** to high **(one to five in our framework)**

The Market Breadth dimension is designed to indicate industry's interest in a technology. Without this information, it would be difficult for the Army to ascertain whether it could find potential partner to perform R&D in the technology area. The market breadth dimension ranges from **Army unique** (the technology has potential use to the Army alone) **to *generic*** (the technology has potential Army and commercial uses).

For each axis (army utility and market breadth) different number of criteria even sub-criteria for each criterion might be determined. According to decision maker knowledge about army's current R&D program, experience with army research and development project, and scientific background, different criteria and sub-criteria that belong to each criterion might be determined. Gathering all related sides, a group decision process based on the qualitative & quantitative data might provide expected and best result. Expert Choice (EC), a methodology for decision-making based on the Analytic Hierarchy Process (AHP) [52] might be useful to establish a forum for discussion in-group decision-making processes. It permits the full range of considerations to be taken into account succinctly and comprehensively. It facilitates discussion of the various aspect of a problem and the expertise of individual group members can be recognized and used.

The following subcriteria were identified and used in the present study:

a. For army utility:

1. Strategic importance
2. Meets initial operational capability date
3. Meets cost objectives
4. Possibilities of application to different project

b. For market breadth

1. Possibilities of dual-use (both military and commercial use) 8
2. Level of competence
3. Market share

The steps of the methodology is:

1. Determining of the sub-criteria for **army utilit**y and **market breadth**
2. Prioritization of the sub-criteria and finding the dependent- weights of the criteria.
3. Evaluating technologies according to determined criteria and scale.
4. Calculating army utility and market breadth dimension's values**.**

In sections 4 and 5, we shall use this approach to assess collaboration possibilities for the case of laser technology for Turkish Armed Forces.

III. R&D PROJECT SUCCESS CRITERIA SURVEY RESULTS

In this secion we identify factors that contribute to R&D project management success. We have made literature survey to determine the CSF in R&D project management. We composed a more general and conceptual list of CSF. This factor list can be used as a general base for all project managers as a reference, which they should evaluate for inclusion in their programs.

In addition to the these CSFs list there must be additional factors that contribute the success of TAF R&D project management, because almost all stages of TAF R&D project process are executed by different organizations. We generated a list of factors in eight categories. Areas addressed include program management, P-S-O (People-System-Organization) requirements.

The questionnaire was developed to help the respondents identify what they felt were key factors of R&D project management. In the first part of the questionnaire there are 13 factors. These factors were extracted from literature. In the second part of the questionnaire there are 15 factors. These factors were modified from an study [15] that is about identifying factors that contribute to the program success in the US Army.

44 individuals participated in the survey. This response number is judged sufficient to validate the survey results.

A. Indicators of Project Success

1). Survey 1 Results

The responses to the first survey question "Please rank the following in order of their importance as indicators of project success" are presented in Table 3.1.

2) Survey 1 Analysis

The survey results were analyzed to select key factors considered important by the respondents. These factors were ranked in order of importance and categorized into common subject areas. With these results in hand, we compiled a list of factors that contribute to R&D project success. Figure3.1 shows graphical presentation of the responses to the first part of the survey questions.

According to Project manager/members from Ministry of National Defense Undersecretaries for Defense Industries, and TAF, four factors:

1. Project mission/ selecting of the R&D project (with average 4,8 value)
2. Commitment of project staff (with average 4,1 value)
3. R&D process well planned (with average 4.0 value)
4. Project schedule, Timing(with average 4,8 value),

were deemed very important.

Market existence were judged last in level of importance with 3,0 average value.

Second group is Project manager/members from defense industries firms. They felt that :

1. Project mission/ selecting of the R&D project (with 4,4 average value),
2. Commitment of project staff (with 4,3 average value) ,
3. High level management support (with 4,1 average value) ,
4. R&D process well planned (with 4,1 average value),

were very important. "Need to lower cost" was judged last in importance with 3,1 average.

Last group is Post Graduate students from TAF who might be candidate for these projects in the future; they have not participated in any project in TAF. They evaluated the factors according to their project management knowledge. They felt that;

1. Project mission/ selecting of the R&D project (with 4,3 average value)
2. Commitment of project staff (with 4,3 average value)
3. High level management support (with 4,2 average value)
4. Communication (with 4,1 average value)
5. Project schedule, Timing (with 4,0 average value)

were important.

Market existence was judged last in level of importance with 3,1 average value.

TABLE 3: THE RESPONSES TO THE FIRST PART OF THE SURVEY QUESTIONS

No	Critical Success Factor	I			II			III		
		Avr.	Mode	Std ***Dev***	**Avr.**	Mode	Std ***Dev***	**Avr.**	Mode	Std ***Dev***
1	Project mission/ selecting of the R&D project	4,8	5	0,5	4,4	5	0,8	4,3	3	5
2	High level management support	3,9	4	0,5	4,1	4	0,7	4,2	4	4
3	Probability of technical success	3,6	4	0,8	3,3	3	0,9	3,4	3	4
4	Market existence	3,0	3	1,0	3,5	4	0,5	3,1	3	4
5	Availability raw materials	3,4	4	0,9	3,4	3	0,6	3,3	2	4
6	Need to lower cost	3,4	4	0,9	3,1	3	0,8	3,1	5	3
7	Project schedule, Timing	4,0	4	0,9	3,8	4	0,7	4,0	4	4
8	Commitment of project staff	4,1	4	0,6	4,3	4	0,6	4,3	5	4
9	R&D process well planned	4,0	4	0,9	4,1	4	0,7	3,5	3	4
10	Monitoring and feedback	3,9	3	0,8	3,7	4	0,4	3,5	4	3
11	Selecting and training and experience of own people	4,2	4	0,7	3,9	4	0,8	3,9	4	4
12	Communication	3,9	4	0,7	3,4	4	0,9	4,1	2	4
13	Trouble shooting	3,8	4	0,6	3,8	4	0,7	3,6	3	3

1 = Not very important
2 = Somewhat important
3 = Important
4 = Very important
5 = Critical
I : Assessment of project manager/members from Ministry of National Defense, Undersecretaries for Defense Industries and TAF
II : Assessment of project manager/members from Defense Industries Firms.
III: Assessment of TAF officers selected for PG education at system engineering who are might be candidate for project manager/member in the future

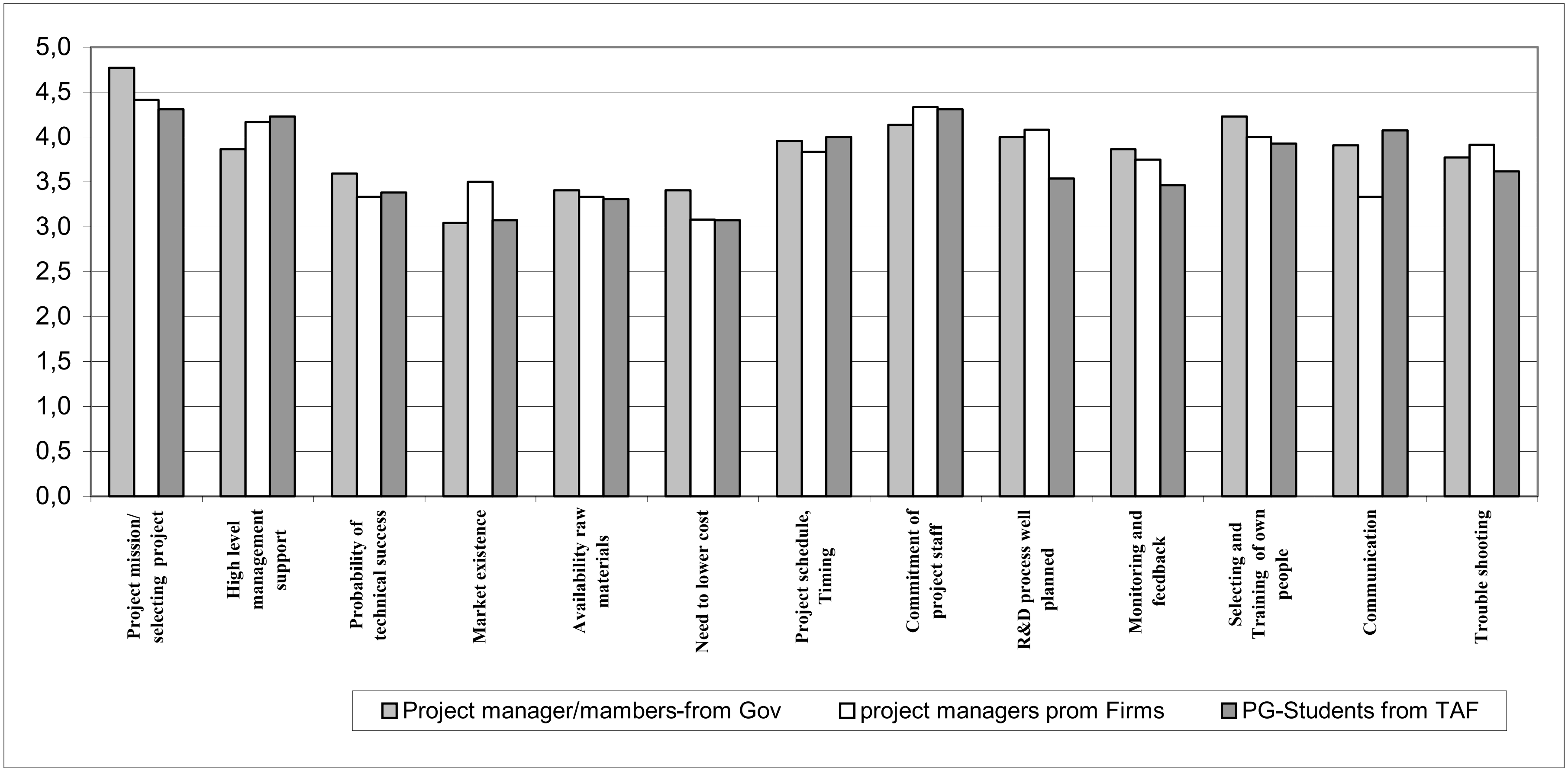

Figure 3: Graphical Presentation of the Responses to the First Part of the Survey Questions

It can be concluded that commitment of the project member might be high in the project that's mission and goals are clearly defined and has top management support.

Examining Table 1, it should be noted that there is great consensus on seven factors according to their minimum, maximum, average, and standard deviation.

These factors are:

1. Project mission/ selecting of the R&D project
2. High level management support
3. Probability of technical success
4. Monitoring and feedback
5. Commitment of project staff
6. Project schedule, Timing
7. Selecting and Training and Experience of own people

An important outcome of the first part of the study is an empirical verification of literature analysis based critical success factors.

B. Success Factors for Military Programs

1) Survey 2 Results

The responses to the second part of the survey question "Please rank the following in order of their importance as indicators of project success" are presented in Table 4.

TABLE 4: THE RESPONSES TO THE SECOND PART OF THE SURVEY QUESTIONS

No	Program Success Factor	I			II			III		
		Aver.	Mode	Std ***Dev***	**Aver.**	Mode	Std ***Dev***	**Aver.**	Mode	Std ***Dev***
1	Program manager's ability to communicate	4,1	4	0,7	3,8	3	0,8	3,6	4	0,7
2	Type and quality of people associated with program	4,1	4	0,4	4,1	4	0,5	4,0	4	0,8
3	Program manager's ability to lead	3,8	4	0,7	4,1	4	0,5	4,1	4	0,8
4	Good relationship with the user organization	3,6	4	0,9	3,9	4	0,7	3,2	3	1,0
5	Product requirements and design stability	3,4	3	0,8	3,6	4	0,9	3,2	3	0,9
6	Good relationship with the contractors firm	2,7	3	0,7	3,5	3	0,8	3,2	3	1,0
7	Program's acquisition strategy	3,5	3	0,7	3,5	4	1,0	3,6	4	0,8
8	Program manager's acquisition experience	3,4	4	0,9	3,9	4	0,8	2,6	3	1,0
9	Program personnel continuity	4,0	4	0,8	4,4	4	0,6	3,5	3	0,9
10	Program manager continuity	3,8	4	0,9	4,1	4	0,9	3,8	4	0,9
11	Degree of technical difficulty	2,8	3	0,8	2,9	3	0,9	2,9	2	0,8
12	Program manager's field experience	2,5	2	1,0	3,2	4	1,0	3,5	3	1,2
13	Program manager's technical ability	3,0	4	0,9	3,1	3	0,9	3,7	4	0,9
14	Total quality management program	3,3	3	0,9	3,1	3	1,1	3,2	4	1,0
15	Needed law and regulations	3,0	3	0,9	4,0	5	0,9	3,2	3	0,7

1 = Not very important
2 = Somewhat important
3 = Important
4 = Very important
5 = Critical
I: Assessment of project manager/members from Ministry of National Defense, Undersecretaries for Defense Industries and TAF
II: Assessment of project manager/members from Defense Industries Firms.
III: Assessment of TAF officers selected for PG education at system engineering who are might be candidate for project manager/member in the future

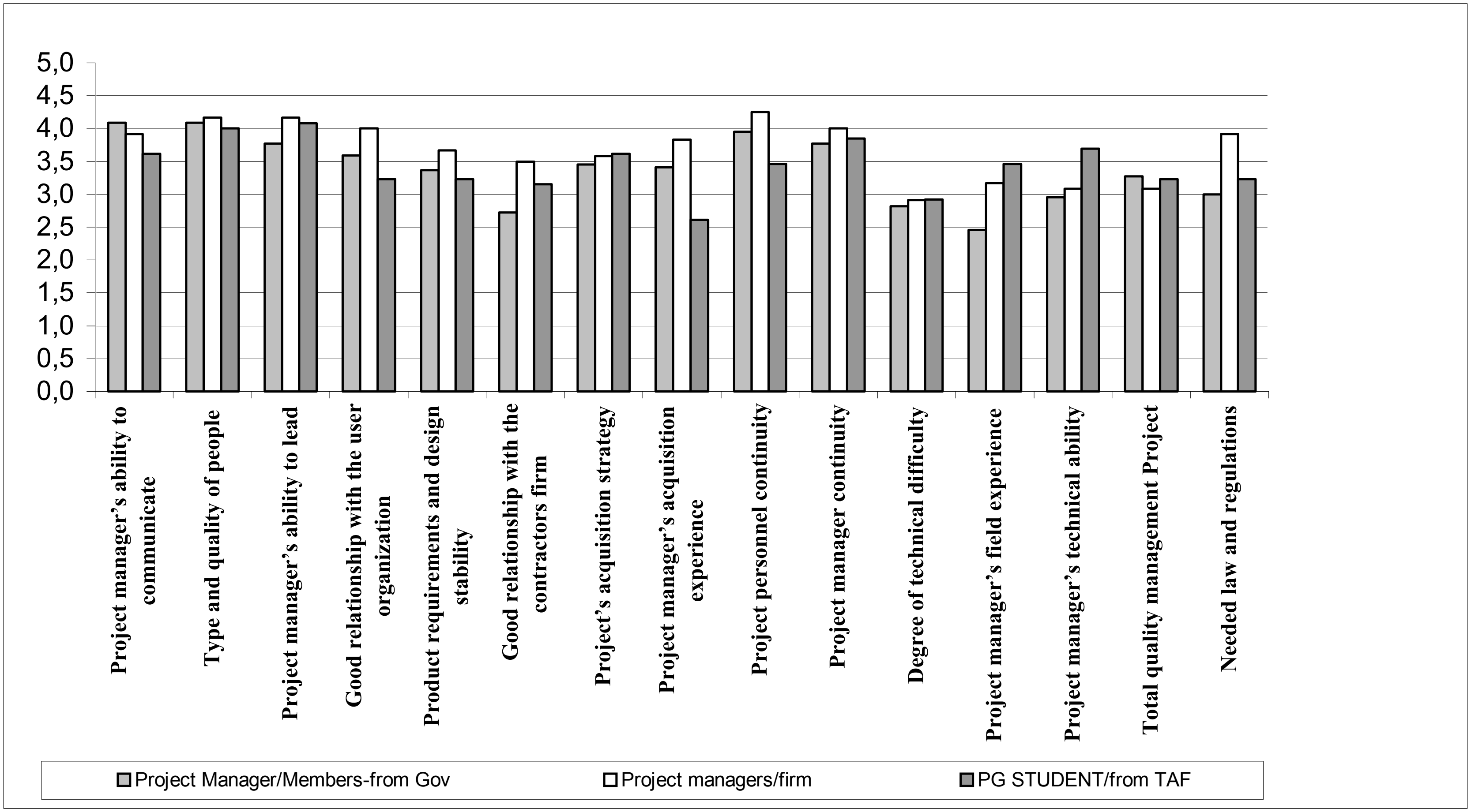

Figure 4: Graphical Presentations of the Responses to the Second Part of the Survey Questions

2) Survey 2 Analysis

According to Project manager/members from Ministry of National Defense Undersecretaries for Defense Industries, and TAF, four factor,

1. Program manager's ability to communicate (with 4,1 average value),
2. Type and quality of people associated with program (with 4,1 average value),
3. Program personnel continuity (with 4,0 average value),
4. Program manager continuity (with 3,8 average value), were deemed very important.

Two factors *Good relationship with the contractors firm* and *Program manager's field experience* were judged last in level of importance

Second group is Project manager/members from defense industries firm. They felt that :

1. Program personnel continuity (with 4,4 average value),
2. Program manager continuity (with 4,1 average value),
3. Program manager's ability to lead (with 4,1 average value),
4. Type and quality of people associated with program (with 4,1 average value),
5. Needed law and regulations(with 4,0 average value),

"*Degree of technical difficulty*" was judged last in level of importance with 2,9 average value.

Last group is Graduate students from TAF. They felt that;

1. Program manager's ability to lead (with 4,1 average value)
2. Type and quality of people associated with program (with 4,1 average value),

were very important.

"Degree of technical difficulty" (with 2,9 average value), and "Program manager's acquisition experience" (with 2,6 average value) were judged last in level of importance.

An important outcome of second part is that "People" related factor were evaluated most important by each group. This could mean that most of the problem in the R&D project management might be resulting form people-related factors rather than system and organization factors.

Examining Table 2 it should be noted that there are great consensus on seven factor according to their minimum, maximum, average, and standard deviation. These factors are:

1. Type and quality of people associated with program
2. Program manager's ability to communicate
3. Program manager continuity
4. Program's acquisition strategy
5. Product requirements and design stability
6. Program manager's ability to lead
7. Total quality management program

As can be seen from the Figure 4, "people" related factors were evaluated most important by each group in both part of the survey. This might denotes that Project success often depends to a considerable extent on member-generated performance norms and work processes, rather than supervision, policies and procedures.

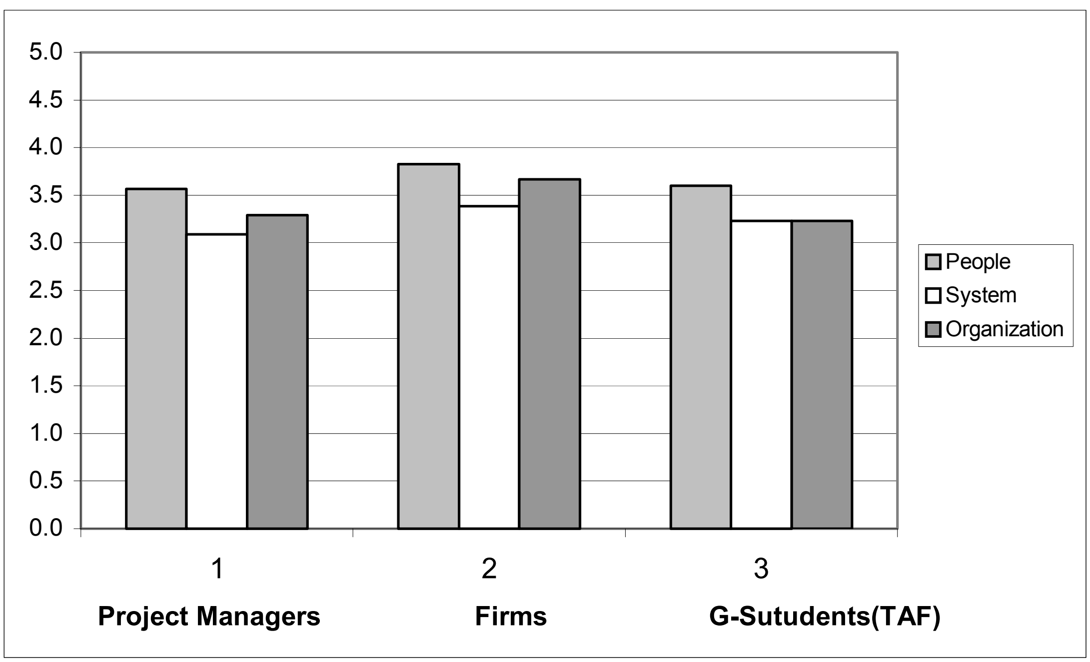

Figure 5: Graphical Presentations of the first part of the Responses as P-S-O

The factors that we have provided here give project members points of reference, which they should evaluate for inclusion in their project. These factors are widely recognized as contributing the program success by the current literature and by our population.

As can be seen from the result “People” related factors were evaluated most important by all responded. This might denote that project success often depends to a considerable extent on member-generated performance norms and work processes, rather than supervision, policies and procedures.

IV. METHODOLOGY FOR SELECTION AND MANAGEMENT OF TAF R&D PROJECTS

47 individuals ranked the subcriteria mentioned section 2 using AHP. [52] The results can be found in Table 5 and 6.

TABLE 5: AHP RESULTS FOR ARMY UTILITY

Army Utility	Meets initial operational capability date	Strategic importance	Possibilities of application to different project	Meets cost objectives
Meets initial operational capability date	1	0,91	1,42	1,13
Strategic importance	1,09	1	1,56	1,25
Possibilities of application to different project	0,73	0,64	1	0,81
Meets cost objectives	0,87	0,8	1,25	1

TABLE 6: AHP RESULTS FOR MARKET BREADTH

Market Breadth	Market share	Rate of competence	Possibilities of dual- use
Market share	1	0,8	0,48
Rate of competence	1,25	1	0,6
Possibilities of dual- use	2,08	1,66	1

Applying Expert Choice program we find depended weight of each subcriteria as follows:

For army utility:

1. Strategic importance ……………………………0,30
2. Meets initial operational capability date..……..…0,27
3. Meets cost objectives ……………………………0,23
4. Possibilities of application to different project…..0,20

For market breadth

1. Possibilities of dual- use (both military and commercial use) ….………………………………0,48
2. Rate of competence….…………………………...0,29
3. Market share..……………………………………0,23

After determining of the criteria for **army utilit**y and **market breadth** and prioritization of the subcriteria and then application of the AHP for finding the weights of the criteria, determined critical technologies might be evaluated according to determined criteria and scale that belongs to each criterion. Decision marker or project team should evaluate each criterion according to their knowledge, experience, and preferences . A scale might be generated based on both qualitative and quantitative data in order to help decision maker.

And then the final values of army utility and market breadth axis are found for placement of technology to the framework In other words we find two values (1 </= X, Y <= 5) for X and Y axis.

X-axis values (**Army Utility**) and Y-axis values (**Market Breadth**)

$$= \; w_i \; * \; k_i$$

w_i = dependent weight value belongs to i criteria
k_i = scale value belongs to i criteria (1 </= k_i <= 5)

After placing the technology to the framework we see that which technology falls into which part of the management domains. The framework helps us categorize the technologies by management domains. And strategies approaches and cost, time, and quality characteristics must be determined for each management domain. Because when we look at army point of view, strategies approaches and cost, time, and quality characteristics of each management domain must be different. In this manner interpretation of the results of framework application might be provide some guidelines for army for determining appropriate strategies.

Many of the important technological areas for the Army, such ac information and communication technologies, are now dominated by commercial firm. TAF must seek the ways to exploit industry's capabilities, especially in areas where the commercial sector holds the technological edge. For TAF one of the most common ways to reduce R&D costs is to form partnerships with other firms to carry on joint R&D activities.

In the last part of this study we offered an approach to determine whether there are any technologies suitable for collaboration with industry. Our methodology may create the significant preconditions for determining the strategies and R&D objectives for selecting and management of R&D project.

With this collaboration and sharing of the cost, information and capabilities among the partner firms provide TAF long-term beneficial result.

A. Evaluation Criteria and Their Scales

1) Army Utility

Army Utility reflects a technology's potential contribution to helping the Army accomplish its mission. In the framework Army utility is represented as a continues scale that ranges from ***low*** to high **(one to five in our framework).** A technology with low Army utility is one that is not expected to contribute directly to the Army's future combat capability. On the other hand, a technology that is critical maintaining future combat capabilities has high Army utility. And criteria for selected for army utility might be ranked as given in Table 7. There is not any determined scale for "strategic importance" and "possibilities of application to different project " criterion. Each criterion must be evaluated by decision marker or project team according to their knowledge, experience, and preferences or a scale might be generated based on both qualitative and quantitative data.

TABLE 7: EVALUATION CRITERIA AND THEIR SCALES – ARMY UTILITY

Criteria / Scale	Rank	Meets initial operational capability date	Strategic importance	Possibilities of application to different project	Meets cost objectives
High	5	<= 1 years	5	5	$0 - $ 500.000
B	4	1 - 3 years	4	4	$ 500.000 - $ 1.000.000
Medium	3	3 - 5 years	3	3	$ 1.000.000 - $ 5.000.000
D	2	5 - 10 years	2	3	$ 5.000.000 - $10.000.000
Low	1	>= 10 years	1	1	$10.000.000 +

2) Market breadth

The Market Breadth dimension is designed to indicate industry's interest in a technology. Without this information, it would be difficult for the Army to ascertain whether it could find potential partner to perform R&D in the technology area. The market breadth dimension ranges from **Army unique** (the technology has potential use to the Army alone) **to *generic*** (the technology has potential Army and commercial uses).

If a technology has many potential army and commercial uses ,then industry's interest is likely to be higher than if the technology had potential use for the Army only (Army unique). Because of growth in international technological capabilities and increased competition most of the commercial firms want to have latest technology. Furthermore, most of the commercial firms hold the technological lead in many areas important the Army. So their rate of contribution to R&D studies, product, and services might be high.

Criteria for market breadth and their scales are given in Table 8. There is no determined scale for market breadth criteria. Decision marker or project team should evaluate each criterion according to their knowledge, experience, and preferences . A scale might be generated based on both qualitative and quantitative data in order to help decision maker.

TABLE 8: EVALUATION CRITERIA AND THEIR SCALES – MARKET BREADTH

Criteria / Scale	Rank	Market share	Level of competence	Possibilities of dual-use (Both military and commercial use)
High	5	5	5	5
B	4	4	4	4
Medium	3	3	3	3
D	2	2	2	2
Low	1	1	1	1

V. APPLYING THE METHODOLOGY TO LASER TECHNOLOGY PROJECT

As an example we assessed the laser technology

A. ARMY UTILITY

Army utility reflects a technology's potential contribution to helping the Army accomplish its mission.

Meets initial operational capability date

There are limited countries that have laser technology. There is no firm that have laser technology in our country. To have this technology might require many years basic research and might take more than ten years. Under these conditions we evaluated its value as 1 (low).

Strategic importance

There are many usage area of laser technology for military purposes. Current military uses of laser systems (both hand-held and mounted on vehicles or aircraft) include rangefinding or distance measurement, tactical target designation, and simulation of ballistic characteristics for training purposes. Lasers can also be used as part of fire-control systems and in conjunction with night-vision and infrared -sensing technologies. To have these technology might give many advantages to any country such as cost reduction, affective use of weapon system, competitive advantages, etc. Because of this reasons we evaluated its value as 5 (high).

Possibilities of application to different project

If we have this technology, we can apply it to many other weapon systems in order to increase their effectiveness. Other new applications of it might be in communication area. Relatively safe, low-powered lasers that are being developed for guided optical communication systems or fiber optic networks, and short-to-medium range or line-of-sight communicators. Also, with the development of technology, very high power lasers will be used in directed energy warfare to engage targets as a direct-fire weapon. The laser will transfer high invisible energy to a target and cause the target, or one of its critical components, to overheat and malfunction. And in the light of these reasons this criterion is evaluated as 3 (medium).

Meets cost objectives

The cost of possessing a critical technology, like laser might be higher than we estimate. And the cost of possessing laser technology is evaluated more than 10.000.000 $. So its value ranked as 1 (low).

TABLE 9: ARMY UTILITY SCORE OF LASER TECHNOLOGY

ARMY UTILITY			
Criteria	Depended Weight	Assessment Value	Total
Meets initial operational capability date	**0,27**	1	0,27
Strategic importance	**0,30**	5	1,50
Possibilities of application to different project	**0,20**	3	0,60
Meets cost objectives	**0,23**	1	0,23
		Total	2,60

B. MARKET BREADTH

The Market Breadth dimension indicates industry's interest in a technology.

Market share

As far as to our knowledge laser technology is used only in security and medical purposes because of this its value is determined as 2.

Level of competence

Because of the high cost of laser technology there is not many firm interested in this technology. So it is difficult talking about competence. And its value determined as 1(low).

Possibilities of dual-use (both military and commercial use)

There might be many applications of laser technology for commercial purposes. For example in medical science, dermatologists have used lasers since the 1960's for the treatment of skin lesions, although generalized acceptance of laser therapy has occurred only in the last few years. Most recently, revolutionary technological advances have improved lasers to the point where they now offer significant advantages over standard techniques used for the treatment of skin blemishes, tumors, birthmarks and facial aging changes. Specific lasers are chosen based on the condition one wishes to treat[1].

And also the Laser has grown up to bea flexible tool for many measurement and manufacturing techniques in natural scientific applications, medicine and environmental diagnostics. Because of the high probability of dual use in many commercial areas its rank evaluated as 4.

TABLE 10: MARKET BREADTH SCORE OF LASER TECHNOLOGY1

MARKET BREADTH			
Criteria	Depended Weight	Assessment Value	Total
Market share	**0,23**	2	0,46
Level of competence	**0,29**	3	0,87
Possibilities of dual-use	**0,48**	4	1,92
		Total	3,25

[1] www. laser surgery.com

We can see the TAF point of view to the laser technology in Figure 6. As can be seen from the figure laser technology falls into or participate domain according to our application. Technologies that fall in the participate domain have moderate market breadth and moderate Army utility.

Under tight fiscal constraints, neither the Army nor industry will have enough funds to invest much in these technologies. Collaboration may allow the Army and industry try to pool resources to perform research and development in these areas. However, the Army may not want to spend more effort to proactively initiate research activities. For technologies in this domain, both the Army and industry can design and participate in activities for mutual benefit. Such efforts may require both the Army and industry to compromise on a set of R&D goals. Without a willingness to adjust goals, a joint investment may not be attractive enough to either the army or potential industry partners.

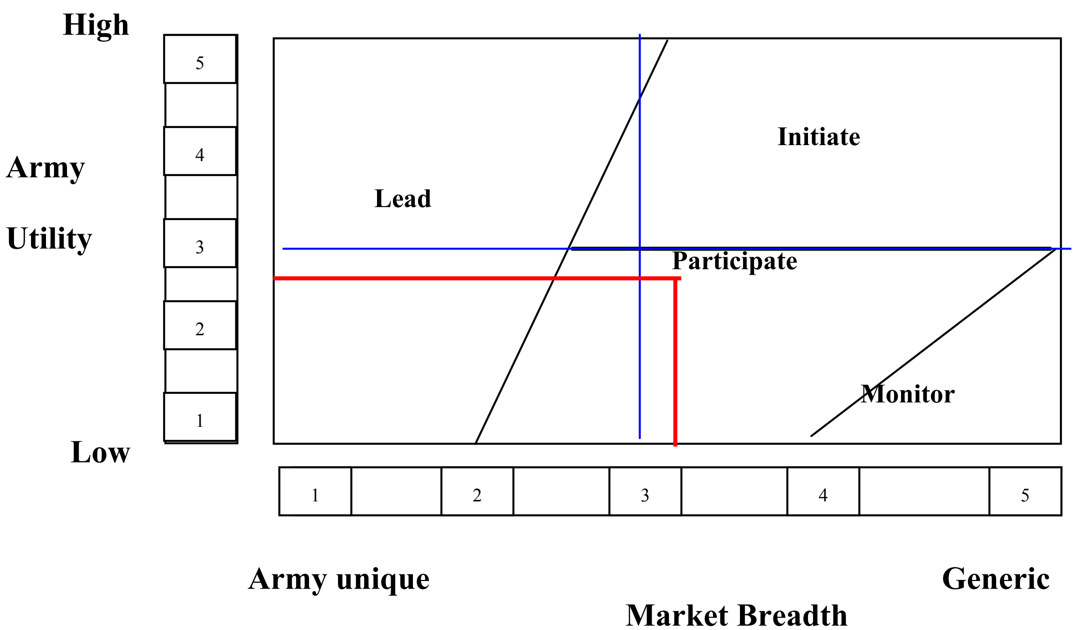

Figure 6: Location of Laser Technology in the ArmyUtility/Market Breadth Matrix

VI. CONCLUSION

Defense acquisition system is a system whereby all equipment, facilities, and services that are needed for TAF are planned, developed acquired and maintained. Procurement, technology transfer, and research and development are there main way used by any nation in order to achieve its defense requirements. The science and technology policy of the TAF consist of principle and methods, play an important role for organizing the country's potential core competitions and developing national industrial base, as a part of the overall national development policy.

With the integration of science and technology processes, science and technology activities and studies can be directed to national defense requirements. We make use of national resources and national industrial base and expenditures and source of funds. TAF might use their defense acquisition program in order to improve national capacity building

In this study we focused on management component of defense system acquisition and we aimed to determine the critical successful factors in R&D project management in defense system acquisitions. Though the review of literature,selecting project manager/members from Ministry of National Defense Undersecretaries for Defense Industries, TAF, project manager/members from defense industries firms that do business with the TAF, as well as officers selected for graduate program in systems engineering who might be candidate for project manager/member in the future, we wanted to learn their evaluation about these critical success factors composed of literature survey.

The factors that we have provided here give project members points of reference, which they should evaluate for inclusion in their project. These factors are widely recognized as contributing the program success by the current literature and by our population.

As can be seen from the result "People" related factors were evaluated most important by all responded. This might denote that project success often depends to a considerable extent on member-generated performance norms and work processes, rather than supervision, policies and procedures.

In this study, we have tried the define critical success factors according to our population knowledge and experience. In fact we believe that examining the past project and interviewing with the project mangers or members to investigate the causes of the success or failure and learning their believe about what is the success indicator of an R&D project and evaluate the resulted project might be more useful. But, because of the time constraints and some difficulties about the reaching the information and people because of the discontinuity of the TAF member, we couldn't perform such a study. Also, such a study that defines not only the factors but degree of contributions to the R&D project success by applying AHP might be provide us more useful guidance.

Applying Expert Choice (EC), that uses (AHP), we can find the not only factors that contribute to the project success but also each factors contributions to the R&D project success.

Last part of our study we made an analysis of collaborative research opportunities for TAF. And we proposed a new methodology for selecting R&D project and to determine whether there are Army technologies suitable for collaboration with industry.

We believe that TAF might have significant opportunities to more effectively achieve its research and development goals trough collaboration with industry. Sharing of the cost, information and capabilities among the partner firms provide TAF long-term beneficial result. We believe that almost having beginning of its s-curve defense industry needs collaboration of government- university and industry. Clearly defined strategy and R&D objectives create the significant preconditions for successful R&D project management.

Universities, state and private R&D organizations, defense R&D institutes and organizations (TAF, MoND) should play a co-evolutionary role to complement each other. Progressive, effective, productive and beneficial result can only be achieved in this way.

TAF needs, critical technologies and technological and R&D capabilities must be taken into account when determining the candidates for R&D collaboration. Determining the candidates and their technology and R&D capabilities for collaborations as important as determining the technologies.

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