A Methodology and Audit Tool for Dual-Use New Product Development: Results from Turkish Companies

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Abstract - New technologically related products must be developed to make attempts to enlarge the market base in the current competitive environment. Dual-use technology which enables the companies to use both military and commercial applications in the same product will provide such type of opportunity for the firms.

This article will propose systematic approaches for dual-use product development and a methodology for that difficult integration process. In order to accomplish this purpose, new product development models and dual-use technology in literature are analyzed and an expanded dual-use new product development model is proposed which has five main phases according to Goal Project Directed Management rules. The paper represents performance and process audit for the model applied to eleven companies from Turkey with a questionnaire and results are evaluated according to model activities.

Key Words: New product development, dual-use technology, Goal Project Directed Management, stage-gate process, technoogy transfer, reliability analysis, factor analysis.

I. INTRODUCTION

New product development process is difficult to manage, but at the same time so vital for company's growth and prosperity. Cooper [30] defines the product development process as a disciplined and set of tasks and steps which a company converts ideas into products or services. Many academics and business managers agree that the most essential element for a company's long-term survival is related to success in new product development. New product is the most important success factor for the companies, because customer needs change so rapidly. Competition increases faster between the companies at home and abroad. Competitive pressures forces them to bring new products to market faster, offer them at reduced cost and deliver the products with levels of quality [77].

The development of new products in a company not only opens new markets and attracts new customers, but also helps the company to enlarge its organization capabilities and to provide higher quality on the final products. This is difficult work to manage and many companies are seeing product development as a core capability of the business [104].

New product development shows necessary stages and activities from idea to launch of new product [8] and if there is no systematic approach to these phases in the company, the failure will be inevitable. The failure in new product development for a company means additional costs, lost time and customers or markets which are the most essential competence tools for the company in a competitive world. To use systematic approach in new product development will be successful if the new technologies are known and applied by the company during the development process.

To combine the technologies together in a product development process will require engineering capability and R&D capability for the companies too [16]. To integrate new technologies to development process will provide advantages about cost, time and market to the companies. One of these technologies which will be integrated into development process in this study is "dual-use technology". This is the technology with current or potential military and civilian applications [47]. Dual-use *refers to a product, process, or a technology which satisfy military needs while also exhibiting commercial viability in the competitive marketplace [123] and* Dual-use Technology r*efers to fields of research and development that have potential application to both defense and commercial production* [38].

All companies are in need of creating new markets for their products to be strong in the competence world. They also have to lower the costs to attract the customers. Customers always prefer the products which give satisfaction about quality in accessible costs. External and internal dimensions of the product development process [92] are very important at customer satisfaction.

Dual-use new product development will give an opportunity to both defense and commercial companies about having these advantages. Defense and commercial producers will have a strong market base in military and also markets in commercial sectors with dual-use products.

Implementing a dual-use new product development requires changes in attitudes and in organizational structure as a whole. Four basic questions about new product development model [85] must also be asked by companies for dual-use new product development.

Every department in the company has to believe that managing such a product development's advantages for the firm. Companies have difficulties about changing long-standing procedures in their own structures. There will be always reluctance to the changes in the companies especially by old practitioners. But the competence environment changes rapidly day by day and doesn't accept the companies in the stable state. So the problem about the organizational structure changes must be solved before beginning to dual-use new product development process. The companies will be differentiated by the applications of the successful products in the future.

The purpose of that article is to propose systematic approaches for dual-use product development and to show a methodology which enables both military and commercial companies to develop dual-use products. This model will integrate dual-use feature and will have activities from idea generation to launch and the management of the markets.

II. LITERATURE REVIEW

In this section we will review the literature on dual-use product, process, technology and new product development with the aim of extracting questions for our audit tool.

A. Dual-use Technology

1. Definition of Dual Use

There are many definitions of dual-use which are used by both military and commercial sectors applying the concept differently to support their positions.

A comprehensive definition of dual-use is encountered in *Adjusting to the Drawdown: Report of the Defense Conversion Commission* [38], where dual-use is interpreted according to whether it is used in reference to products, processes, or technologies. In this paper definitions are given according to these properties:

1. Definition of Dual-use Products: *These products are items used by both military and commercial customers.*
2. Definition of Dual-use Processes: *These processes are those that can be used in the manufacture of both defense and commercial products, such as soldering, process control, and computer-aided design.*
3. Definition of Dual-use Technology: *Refers to fields of research and development that have potential application to both defense and commercial production.*

Another variant of Dual-use definition by White et al. [123] explains the term as "*a product or process that has both commercial and military applications might be dual-use and employed militarily but not commercially because of cost, performance, regulations, or other considerations.*" There is a critical point at this definition. It is very important to clearly distinguish between dual-use and commercial-military integration (CMI):

> *Dual-use refers to a product or process that has both military and commercial applications and in the case of dual-use technologies; this extends to knowledge that is applicable in both sectors. Therefore the concept of dual-use relates to the characteristics of a product, process or know-how without regard to the desirability of its application in either sector. Hence, an item might be dual-use and employed militarily but not commercially because of cost, performance, regulations, or other considerations.*

CMI, on the other hand, is a process that seeks to exploit the "dual-usefulness" of products or processes to arrive at more efficient and cost effective solutions jointly for the commercial and military sectors. Commercial-military integration is achieved when the production of commercially viable and military useful products is conducted jointly using common production inputs and outputs are sold at prices to those set by commercial markets. Note that this definition involves two dimensions; an engineering one, ensuring the commonalty of resources and production techniques, and an economic one, ensuring the comparability of costs and prices. In this study also, commercial-military integration will be tried to be achieved in the model of new product development and this definition is very important for the study.

Another definition explains the dual-use as with respect to products, services, standards, processes, or acquisition practices, means products, services, standards, processes, or acquisition practices, respectively, that are capable of meeting requirements for military and nonmilitary application [123]. The definition of Gallart [47] about dual-use is also very simple: *Any technology with current or potential military and civilian applications can be said to be dual-use.*

We will employ the following definition in this paper:

> *Dual-use refers to a product, process, or technology which satisfies military needs while also exhibiting commercial viability in the competitive marketplace.*

2 Dual-Use Models

Buchanan [14] suggests the following strategy rules in the overview for the Defense Manufacturing Council in USA:

1. Whenever possible, avoid military-unique development and buy commercial,
2. Trade off military and commercial needs to find the opportunity,
3. If feasible, co-develop dual-use products with industry, or
4. Develop military-specific solution.

There had been different models definitions about dual-use between White et al. [123] and Barratino [5]. But in general the models of two studies are not so different. According to White et al. [123] four models of dual-use can be expressed as below:

1. Purposeful Spin-off
2. Direct Spin-off
3. Indirect Spin-off
4. Industrial Base Strengthening

3 Dual-use Technology Space

The way of thinking about changes that lead to increased military reliance on dual-use is very important and named as "Dual-use Technology Space" by [123]. In the Figure 1 along the vertical axis there is a simple, four stage model from purely military to purely commercial requirements. Inside the figure are three areas, one each for military-unique,

commercial-unique, and dual-use products, processes, and technologies. Increased use of dual-use technological and industrial capabilities by the military is represented by a migration of the diagonal lines in the figure in the northwesterly and northeasterly directions, resulting in a shrinkage of military- and commercial-unique applicability.

4 Ways of Technology Transfer from Military to a Civilian Application

The many forms of dual-use technologies lead to a large number of ways in which they can flow between military and civilian applications. Three main ways in which the technology may be transferred from a military application to a civilian application (or vice versa) are given as below [47]:

1. Straightforward Transfer
2. Transfer with adaptation
3. Integration of Military and Civilian Activities

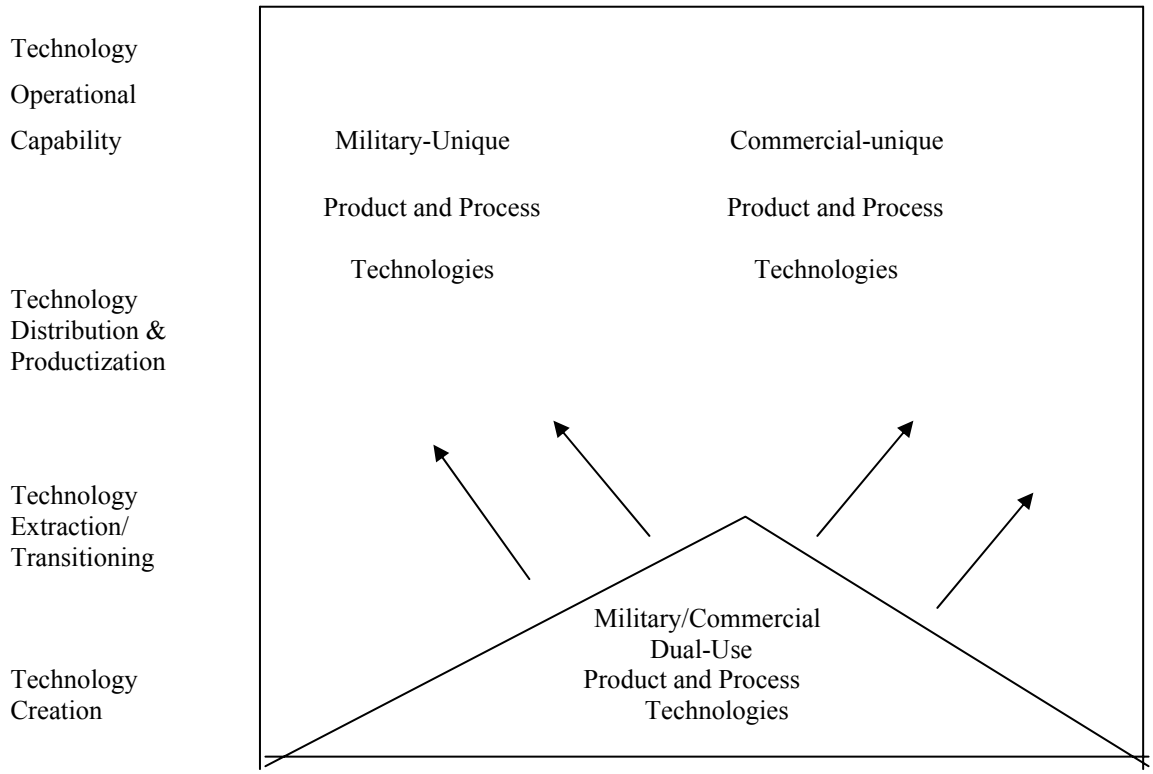

Figure 1: Dual-use technology space [123]

5. Dual-Use Policies

Dual-use policies present some tasks for government, military, commercial and university about dual-use technology development. Because these policies explain some critical points for different situations in the dual-use application. In the dual-use applications either one or more than one policy can be applied by the states. So that to understand the policies deeply will make clear the responsibilities of the different environments about dual-use deployment.

Gallard [47] defines the types of dual-use policies as:

1. Regional Conversion Policy:
2. Co-operative R&D Programs
3. Procurement Reforms
4. Direct Finance of Dual-use R&D
5. R&D Strategies with Dual-use Implications
6. Technology Brokering
7. Improving Communications
8. Converting Facilities to Retain Their Military Capacity
9. Intra-firm Discrete Technology Transfer

6. Dual-Use Responsibilities

a) Military Responsibilities for Dual-Use Development

To motivate both defense and commercial companies about dual-use there are responsibilities of Government and military. Military is important customer for the defense and commercial companies. Military makes the acquisition contracts with firms to buy the products in required standards. If Military will be careful at some points about dual-use in the contracts prepared for companies then this technology can replace among the

companies as a competitive factor. The responsibilities of military for dual-use development are explained by White et al. [123] under these factors:

1. Military have to allow to both military and commercial companies about using COST and co-produced items in some available products.
2. Military should have reliance on commercially viable process technologies.
3. Military should do studies about adoption of commercial management philosophies.
4. Military requirements must be flexible enough to provide fast-changing commercial approaches to product/process definition, design, development, production, distribution.
5. Military must think deeply about in which products security is inevitable and must be designed special for only military according to required specifications of Military and in which products the commercial standards are enough and there is no need of special standards or security barriers.
6. Military needs to look for the ways to improve its acquisition processes [122].
7. High audit standards by military acquisition system should be applied to companies and unique contract requirements from scope of the military [4].

As seen above all these responsibilities are directly related to acquisition reform in military. The need of this reform for dual-use replacement in companies is very important. The methodology of such a reform is not in the interest area of this study.

b) Company Responsibilities for Dual-Use Product Development

Companies which want to focus on dual-use have to prepare some conditions for this technology after regulations of their organizational structures [91]:

1. Companies should look for the personnel familiar with the problems to commercial or military customers.
2. Companies have to establish commercial and military channels of distribution.
3. Companies have to develop customer service infrastructure.

7. Dual-Use Integrated Supplier Management

To manage dual-use in a product development process is also directly related to supplier management in the companies. Dual-use integrated supplier management system can be a tool for this management. This supplier system included [122]:

1. supplier assessment, certification, and selection systems,
2. technical assistance to suppliers to foster supplier statistical process control (SPC) and total quality management (TQM) capabilities,
3. passing more responsibilities to supplier for design, quality, risk sharing.

Watkins [122] reports several advantages of dual-use integrated management system for the firms:

1. This system is flexible to organizational form. It can integrate supplier systems into organizational form without integrating whole company.
2. This system has commercial practice in defense procurement.
3. This system facilitates cross-program learning and the sharing of the ideas and information between commercial and military programs.
4. Single material system means a single set of suppliers to serve both military and commercial companies. Dual-use integrated management system eliminates the duplication of suppliers in the system.
5. This system provides movement in cooperative supplier relations to more information exchange.

8. The Problems of Defense and Commercial Companies in Dual-Use Applications

Companies will have some problems in dual-use attempts both internal and external to their organizations, and also some problems resulting from government regulations. To learn these problems will help both the companies and government about finding the answers for them. These problems are as below [90]:

1. The most important internal problem facing defense companies is to enter commercial markets. To solve this problem they must develop their sales and marketing capability. Because defense firms are used to dealing with a well-defined and single customer as military. The problem in commercial markets is to learn the ways of working with many customers. They should develop their communication channels and customer service departments to solve this problem.
2. Some dual-use product development applications may require additional investment in machines and equipment. So both defense and commercial companies are in need of raising both working capital and long-term capital of their companies.
3. The most important external problem is identifying a viable commercial market for dual-use application. Because the commercial market for the dual-use application may be risky for the companies and also there can be strong competitors in the commercial market to gain a foothold. The companies must make the detailed market analysis well in the development process to solve this problem.
4. Military restrictions and export restrictions in the contracts about the specifications of the products can

prevent the companies to apply dual-use. This problem can be solved with acquisition reform by military.

9 Areas for Synergy Within the Defense and the Commercial Industrial Base

There are three areas for synergy within the defense and the commercial industrial base [36]:

1. Technology/product Development: In technology planning and coordination the same technologies can be gained together. As a result of competitive product development to common standards for dual-use applications will cause lower costs, higher quality, reliability and higher availability.
2. Manufacturing Capability Usage: If the companies both defense and commercial learn to use of common manufacturing capability then the costs for product development, production and support will be reduced.
3. Buying Commercial: Military benefits buying commercial by using common products, common specifications and standards at viable products.

Achieving synergy will be only with the awareness of government and military about commercial base drivers and commercial requirements for technology, product development and manufacturing processes.

10. Technology Reinvestment And Dual-Use Applications

Advanced Project Research Agency [1] makes the following definition for technology reinvestment: "*Technology reinvestment means the transition to a growing, integrated, national industry capability which provides the most advanced military systems and the most competitive commercial products.*"

So it is so clear with this definition that dual-use applications are managed by applying technology reinvestment activities. There are three broad activities areas in technology reinvestment according to Advanced Project Research Agency [1]:

1. Technology development activities which create new technologies or apply existing technologies to demonstrate viability of new products and processes.
2. Technology deployment activities which disseminate existing technology for commercial and defense products and processes.
3. Manufacturing education and training activities which will strength necessary work capabilities to maintain and improve industrial base in the far term.

Each of these areas is directly related to dual-use applications by stimulating the integration of the military and commercial industrial bases.

11. Benefits of Dual-Use Applications

a) Benefits of dual-use for military and government

Dual-use has benefits for the military and benefits for both defense and commercial companies. The benefits of the dual-use for military will be described from different books and articles below.

According to Kaminski [62]; Military will get better products which are developed faster and at lower cost. Because there will be competition between both commercial and military companies for production of the same product and the military will have chance to choose among different alternatives. Strong, productive and commercial industrial infrastructure will be set up in the country by the help of dual-use applications.

Visconti [120] describes that the increasing partnership government and industry with dual-use applications broadens a commercial sector helping the Defense sector. Combined efforts between military and industry will eliminate the unwillingness of the industry to partner with military. The cost savings of military with dual-use products will be reflected to produce leading-edge technologies for defense.

Murphy and Frankosky [83] explains that maybe the civilian applications don't offer a quick military advantage but it indicates specific areas where such advantages are likely to occur.

According to Gallard [47] dual-use policies will gain flexibility to defense industrial base. Also there will be flexibility in the military contracts done with companies. Military will be quitted to be traditionally more sensitive in all types of products performance and specifications than price of them. Military will see the benefits of dual-use as cost and profitability.

Perry describes another benefit for the military in the book of Fountain [46]: "*The new technologies that are most critical for military like computers, semi-conductors, software, and telecommunications are all driven by the commercial industries. By removing barriers which isolate the military from commercial, these technologies can be gained to military"*.

According to White et al. [123] military requirements about products will be flexible enough to provide fast-changing commercial approaches to product and process definition, design, development, production, and distribution. The primary benefits from dual-use are more affordable products, adoption of new technologies to rapidly operational capabilities, greater industrial base flexibility to foster rapid supply-chain response to the needs of military.

b) Benefits of dual-use for both defense and commercial companies

There are many benefits for defense and commercial companies in dual-use applications. If these benefits are known by the whole company then the motivation for the success in the dual-use product development process will be established. The members

of the company will try to do better in their works for reaching welfare. The commitment to company and to work is the key for the success at dual-use. So the definite benefits will provide this commitment properly within whole company. Both defense and commercial firms will believe to dual-use applications in the new product development in different ways and so will be more eager for dual-use product development activities.

These benefits can be stated from different authors as follows:

1. Dual-use represents an opportunity for defense and commercial companies to expand their market bases and to improve their global competitive positions [123].
2. Dual-use will provide the retention of commercial and defense industries [123].
3. While some years ago defense research was a technological leader in most fields, with dual-use, civilian research will also play the leading role in many areas like computers, electronics, and communications [103].
4. Commercial and defense companies will produce the products at low costs because of the market widening as military and commercial and will be convenient for prices when marketing their products.
5. Commercial and defense companies will learn to insert new technologies to their organizational structure and so will develop the nature of their product development processes.
6. The competition between defense and commercial companies cause every company give more importance on R&D activities and these studies will give more benefits in the long run for the companies.
7. Dual-use will provide positive effects on the new product development processes of the both military and commercial companies. Because dual-use is applicable to all phases of the product development life-cycle [49].
8. Dual-use provides to form useful partnerships within firms. Because maybe company will buy a sub-component of dual-use product from another company to use in dual-use product.
9. The organizational structures of the companies will be in need of regulations by beginning dual-use new product development process. So the traditional structures in the some companies will be quitted by this way.
10. The technological and economic growths of the defense and commercial companies by adopting dual-use will also mean the total growth of the country's economical structure as a whole.

12. Necessary Conditions for Dual-Use Product Decision

There are some necessary conditions for dual-use product decision because this decision is so strategic and risky for the companies. To evaluate the conditions in the companies will be by knowing these important conditions. These necessary conditions are [120]:

1. The decision about dual-use must be made carefully and consciously. The situation of the company must be evaluated for every ways. The technologically, organizational, capability of R&D, and development capability are the factors in this evaluation for the company about giving the dual-use decision.
2. The application of dual-use should be concentrated to the product development process in the early stages. Because the strategies about development process must be defined thinking the product as dual-use in the beginning.
3. Market research about dual-use product must be done in detail. Because market analysis is a key element in successful employment of a dual-use technology strategy.

The importance of the integrating of dual-use to the product development process at the early stages is also described by White et al. [123]: Commercial and military interests must intersect earlier stages of the product development rather than the late or at the commercial purchase stages.

13. Some Specific Dual-Use Product Examples

There are many dual-use product examples in life today. Some examples of the products that are used either for defense and commercial are as below:

1. Global Positioning System (GPS): These devices are made for only military at the beginning for positioning and finding the way at the unknown areas. The price of the devices were expensive because of it is marketed only to military. Then when it is thought that the device is not so critical for security and it can also be used by civilian people, this device is also sold as commercial. At beginning a GPS cost was $34000, weighed 17 pounds and has taken 18 months to procure. After it is also permitted as commercial then the companies made commercial GPS for military use also, and per unit cost was $1300, weighed 3 pounds and has taken half of the time from the beginning ones to procure. It is so efficient example about the benefits of dual-use for cost and time of a product [62].
2. The vehicle tires can be marketed as both in military and commercial.
3. The trucks, automobiles and buses can be marketed as dual-use to both military and commercial.
4. The tinned food of military can also be sold at the markets to civilian customers.

5. Advanced batteries produced by the commercial can be marketed for both military and commercial markets.
6. Electronics design is used as low-cost packaging in commercial while it is used to integrate optical information into electronics systems for military.
7. Advanced polymer composites are used for constructing bridges and are used in portable tactical bridges for the military purpose.
8. The switchboards in the telecommunication sector can be marketed for both military and commercial.

B. New Product Development

1 New Product Development Process

Many researches about new product development process have shown that it is a vital process for most companies' growth and success. Since companies are competing in global and dynamic competitive environment today. To be successful in this dynamic environment companies have to tend to develop new products by thinking new strategies, new technologies and new processes. If the firms develop abilities about generating new products that makes difference in the markets then they will gain advantages.

According to Phillips et al. [92] the product development process means which the products are developed from identification to launch in the market. So it incorporates many activities, from idea to manufacture and sales.

Schmidt [101] also explains the new product development process as a set of activities from idea generation to product launch, which are necessary to introduce a product into the market.

Cooper [30] defines the product development process as a disciplined and set of tasks and steps which a company converts ideas into products or services. Cooper gives an other definition in his another article as: *New product process is a formal blueprint, roadmap, template or thought process for driving a new product project from idea stage through to market launch and beyond.*

Cooper also describes the reason of being concerned about "process" and according to him, all work is a process. If the companies want to gain better results at the end of product development so they all focus on the process that delivered the result.

The new product development process is a methodology for developing a new product. It shows necessary stages and activities from idea to launch of new product [8].

All these definitions outline that some stages and activities from idea to launch of a product exist in a new product development process. So to manage this processes effectively needs systematic approach capability and using new technology capability for the companies. This is difficult work to manage and many companies are seeing product development as a core capability of the business [104]. It is true that to develop a new product that truly makes a special impact on customers is difficult, risky and costly [100]. But economic and market forces are causing the companies about rethinking of this difficult job. Competitive pressures forces them to bring new products to market faster, offer them at reduced cost and deliver the products with levels of quality [77].

New product development has difficult but powerful activities for the companies. Because by developing a product and delivering to markets, company will not only benefit of opening new markets and attract new customers but also will enlarge its organizational capability and will have impacts on final product quality [125].

The technologies in increasing variety used in product development process will also require a broader range for all the members of the company that are directly in this process. But to combine the technologies together in a product development process will also require engineering capability and R&D capability for the companies too [16].

Many companies today are under pressures from customers about taking formal quality management system certification such as ISO 9000 series. So they are in need not only to identify their new product development processes but also to ensure the activities are effective and sufficient to satisfy the requirements for taking these quality certifications. It is not forgotten that this need is directly related to satisfy the need of internal customer requirements which work together for the success of the company [89].

2. External and internal dimensions of the product development

There are some forces for driving the product development process from internal and external. External and internal dimensions of the product development process are given below [92]:

a) External Dimensions of Product Development Process:
   (1) Intense international competition
   (2) Fragmented, demanding markets
   (3) Diverse and rapidly changing technologies
b) Internal Dimensions of Product Development Process
   (1) Product performance
   (2) Product development time
   (3) Product development cost

3. New product development models

There exist many different categorizations of new product development methods. Hart and Baker [51] suggest a generalized new product development process models as:

a) Departmental-stage Models
b) Activity-stage Models
c) Decision-stage Models
d) Conversion Process Models
e) Response Models

4. Approaches to new product development process

There two main approaches to new product development process in the literature [33]:

a) Generalist Approaches: There are many studies about investigating the factors of new product development successes and failures. These studies investigate and measure the different sets of variables and their impacts on new product development projects. These studies are referred to as generalist approaches to new product development.

Gruner and Homburg [50] explain the generalist studies as the ones which include a broad range of possible determinants of new products success and aim at identifying the most important ones among them with an explanatory research design.

b) Specialist Approaches: Another grouping for these approaches are specialist approaches and these approaches concentrate on investigations on one particular area of new product development instead of measuring variables with respect to their impact on new product development outcomes such as the integration of the different functions involved in NPD or strategic orientations for NPD success.

According to Gruner and Homburg [50], specialist studies focus on an in-depth analysis of a limited range of determinants of new product success.

5. Major Failure Reasons Of New Product Development Process

The causes of new product development failure are explained by Cooper [31] as the marketing dominated:

a) The companies underestimate competitive strength or competitive position in market.
b) The companies overestimated number of potential users about product.
c) The companies set the price of the product too high and loose their competitive power in the markets.
d) Companies have technical difficulties or deficiencies with the product in new product development processes.

Another research about the failure reasons give the new product failures because of the weak new development product process as follows [55]:

a) The products did not fit corporate strategic needs for the company.
b) The products couldn't be delivered to end-user on promises because of the launch problems in the process.
c) Lack of competitive point of difference in the company.
d) Products didn't manage minimum sales volume forecast at the beginning of the process.
e) Products did not fill the consumer need in market.
f) Insufficient planning in the process.
g) The company made wrong timing about the market introduction.
h) The new product development process doesn't have enough management support about the project.

Page [88] states the obstacles for successful new product development process as follows:

a) Poor control and follow-up of activities within the new product development process.
b) Poorly defined objectives and inadequate business analysis of the company.
c) The unwillingness of top management about the new product development process.
d) Inadequate financial resources of the company to support the new product development process.
e) Inadequate marketing activities about the product by the company.
f) Insufficient management and organization structure for the new product development process.
g) Bureaucratic nature of the organization.
h) Inadequate human resources in the company for the new product development process.
i) Insufficient communication channels throughout the company for the new product development process.
j) Insufficient time problem to develop the new product for the company.
k) Unwillingness about taking risk by the company for developing new product for the markets.

6. Major Success Factors In New Product Development Process

To bring a new product successfully to the market will be an important achievement for the companies. It is related to balance risk, time, money, resources and other factors in this process at first [93].

Mainly there are two fundamental methods of winning at the new product development process [29]:

a) Doing projects right: Employing true cross-functional teams, doing the up-front homework prior to the development stage, building in the voice of the customer, and getting early, sharp product definition have all been found to impact positively on new product incomes.
b) Doing the right projects: The project selection is as important as project execution and a key to success.

The success factors described by Globe as follows [31]:

a) Companies must recognize the technical opportunity about the new product.
b) Companies must be in need of recognition of the market.
c) Companies must have professional internal R&D management and stuff.
d) Managers must have the ability of taking well-executed venture decisions about product development process.

e) Companies should have many development funds.
f) Company must be a technical entrepreneur.

In the same article of Cooper [31], the success factors described by British SAPPHO institution are as follows:

a) Company has to satisfy the market need.
b) Company must have internal and external effective communication channels during the process.
c) Company has to be oriented to market.
d) The top managers have to give importance about the key individuals in the process.

The features of the successful innovations are given with a study undertaken on European and Japanese firms [119];

a) Companies which had no difficulties in marketing.
b) Companies which have a real product advantage.
c) Companies which understand the market needs.
d) Companies which contact with customers.
e) Companies which have top management initiation.

Another research and study which is made about the facilitators in the new product development process by Rubenstein et al. are as follows [31]:

a) There must be existence of a product champion.
b) Marketing factors such as recognition is very important.
c) There must be internal communication channels in the company.
d) To gather data, for analysis and decision-making there must be superior techniques used in the company.
e) There must be planned approaches to venture management in the company.

Another approach to success factors in NPD can be given as below [51]:

a) The need for interdisciplinary inputs which will provide the collaboration of various professionals in the company.
b) The need for quality inputs to the process. This refers that both technical and marketing information have to be both accurate and timely and must be worked to change the undesired circumstances during the new product development process.
c) The need for speed in the process. One of the most important feature in NPD process is to complete the new product in time and quick before competitors do so.

Smith [105] explains the success factors about new product development defined by Cooper in his article as follows:

a) Differentiated, superior products.
b) Definite, early product definition.
c) To shape front-up activities as competitive, technical, market and financial about the product development process.
d) To execute the marketing actions as well.
e) To execute technological actions as well
f) To use multi-functional teams.

In another study eight major variables have been identified as being associated with the successful development of new products [94]:

a) To see good internal and external communication in the organization as critical to innovative success.
b) To see new product development process as a corporate-wide activity which emphasizes a variety of inputs in the process?
c) Quality management and management style that are characterized by management of high quality, flair and ability.
d) Key individuals characterized by technical manager and business innovator.
e) Good planning and control procedures make valuable contributions to new product development success.
f) To manage efficient development work.
g) To make useful after-sales service of the new product and train the users about the product.
h) To search and understand the needs of customers exactly and do marketing facilities according to this search.

Liberatore and Stylianou [77], describe that the new product development process must be altered to several factors for success as follows:

a) It must include senior management support from beginning to the end.
b) There must be early integration of functional expertise into development effort.
c) The new product development resources and their management in the organization must be available.
d) There must be also an environment that supports the team work.

There are also activities that must be done as pre-conditional in NPD process and these activities are identified as pre-conditional strategic variables for successful innovations [94]:

a) Strategic Factor 1: It is very important to have top management support for new product development from beginning to end of to process.
b) Strategic Factor 2: New product development process must be designed as long-term strategy.
c) Strategic Factor 3: There must be long-term commitment to major projects in the company.
d) Strategic Factor 4: The product development process must have flexibility and responsiveness to change. This will provide competitive advantages for the company in this environment.

7. Lessons from synthesis of these studies

All of these studies about the success of new product development process present some lessons to be applied in this process [31]:

a) Market orientation is very important especially for industrial new products and the information about market needs will play a critical role in shaping the launch strategy.
b) New product success is directly related to management action about product development process.
c) It is so difficult to find the key variables that will make a new product successful. So to draw a systematic way for activities will ensure the managers about success.
d) To think the product as unique that will meet the advantages of the customers and develop the plan on this basis is the central of the success in this process for the companies.
e) To conceive the activities of the launch well and then execute the launch according to this plan is vital to success.
f) The communication and coordination channels in the companies will foster the successful innovations.

These lessons also describe the elements of the product development process as follows [32]:

a) The Product
b) The Customer
c) The Company as a whole and Service Engineers

C. Requirements of an Ideal Product Development Process Model

Barclay et al. [6] states the requirements for an ideal product development process model as follows according to Cooper's study:

1) First it must be sufficient in detail to act as an action guide to managers. But it also must not be so complex as to discourage its use.
2) Second, it must be strongly market orientated, and market research and market planning must be executed well in the process.
3) The model must contain multi-disciplinary features to provide the internal communication between the key groups of the process.
4) The model finally must recognize the risks and high failure risks of new products by evaluating the process as a whole.

1. Four basic new product development questions for model

There are four basic questions about new product development model [85]:

a) Which product should be designed? This question refers to the idea generation of the model.
b) How must the product be designed? This question refers to the product optimization problem of the model.
c) How should the product be introduced on the market? This question refers to the marketing mix optimization problem.
d) What is the anticipated success rate of the new product? This question refers to the prediction of success problem of the model.

2. Methods used in solving of these problems

There are some available methods for the general phases problems of the new product development model. These methods are grouped as follows [86];

a) The Methods Available in Idea Generation:

(1) **Brainstorming:** A systematic group session in which barriers to creative thinking are removed to stimulate the production of new ideas through association.
(2) **Morphological Analysis:** An approach to find a large number of theoretical solutions to a problem by dividing it into smaller parts.
(3) **Synectics:** Problem is converted into much wider problem and the solutions are generated for this alternative problem. At the end these solutions are transformed back into solutions for the original problem.
(4) **Focus Group:** To gather information about the product by establishing session with the customers.
(5) **Interview and Survey:** To prepare interviews and surveys about the new product idea for getting information from the customers.
(6) **Observation of Users:** To observe the customers in the markets and search about their desires for new products.
(7) **Delphi Method:** A multi-survey consisting of several sequential rounds in which a number of experts are asked to give their opinion and vision about the developments and finally feedback is established as a general vision.
(8) **Scenario:** To prepare scenarios about different new products in the markets and look at the interest of customers for each of the product.
(9) **Expert Opinion:** To get directly opinion from experts about a new product development in the markets.
(10) **Product Life Cycle:** To construct the sales and volume of a product as mapping over time resulting in an S-shaped curve will help to determine the life cycle phase in which the market exists.

b) Methods For Product Optimization of New Product

(1) Conjoint Analysis: A quantitative market research that determines how customers make trade-off among a small number **of features or benefits.**

(2) **Quality Function Deployment:** A method designed to help NPD project team identify and interpret the needs and desires of customers. The aim is to establish the importance of product attributes and transform them into technical requirements.

(3) **Concept Test:** A method designed for asking the number of customers to evaluate a particular product concept. It can be explained to the customers in writing or by simple means.

(4) **Prototype Testing:** To test a physical model of the new product in company and in sample customer markets.

(5) In Home Use Test: An approach which provides a number of customers test a new product at their home for a certain period of time. After conclusions are discussed with customers.

c) Methods for Marketing-mix Optimization

(1) Simulated Test Marketing: To simulate the marketing activities planned for new product and see the results in this simulated environment firstly.

(2) Mini-market: To make some experimental sells of new product in mini-markets.

(3) Limited Roll-out: To limit the market risk of new product, this product is first introduced in a small scale with the objective to expand slowly.

(4) Scanner Market: Special test markets that provide supermarket scanner data from panels of customers to help assess the product's performance.

(5) Test Marketing: To launch the product into one or more limited geographic regions in a very controlled manner and measure the customer responses about the new product in these regions.

d) Methods for Prediction:

(1) Computer Prediction Models: To use computer software to predict some data about new product's sells.

(2) Computer Assisted Design: A technology for designers and engineers to use computer for design.

(3) Return on Investment: A standard measure of product profitability, discounted profits over the life of the project expressed as a percentage of initial investment.

D. Systematic Approach to Product Development Process: Stage-Gate Process

A formal process for guiding the product innovation is useful solution to apply the new product development programs. Stage-gate process presents such a systematic approach in the models.

Stage-gate process is a roadmap from idea generation to launch of the new product and each stage proceeded by a Go/Kill decision point or gate. Stage-gate systems break the new product development process into set of stages and each stage consists of a cross-functional and parallel activities. The entrance of each stage is a gate and these gates control and Go/Kill/Hold/Recycle check points [27, 28].

Cooper [27, 28] also describes the historical development of the stage-gate process in the same article. He describes that all the stage-gate produces that are used by the companies take their roots from in much earlier models:

The first-generation scheme for product development was developed by NASA in the 1960s as PPP (Phased Project Planning or Phased Review Process). This was a detailed scheme for working with contractors and suppliers on various space projects.

This process divided development into phases. There were review points at the end of each phase. If the certain prerequisites had been met then the next phase could be began. The method was more than a measurement and control methodology designed to ensure that the proceedings as it should and every activity of the phase was completed on time. So the process was very engineering-driven and it applied strictly to the physical design and development of the product. History has some examples of this Phased Review Process.

The system brought discipline, reduced the technical risks and ensured the completion of tasks. But this system was slow. Because the projects could be held up in a queue for a management review or maybe be put on hold at a review point awaiting the completion of one behind-schedule task. It was also narrow because it only dealt with development process not with the process from idea to launch. It was too functional and so narrowly focused on the technical or engineering side of the project.

After this stage-gate models comes new second-stage models. These models also resemble to Phased Review Process of the 1960's. They also have discrete stages preceded by review points or gates. But the lessons learned from the studies about successful and unsuccessful products added some new features to this second-generation stage-gate systems and Cooper [27, 28] stated these in his study as follows:

1. This stage–gate system is very much cross-functional. It is stated before that Phased Review Process was largely an engineering methodology. By contrast the stage-gate process today involves activities from many different departments in the corporation. Stages are not owned by any department. Instead of it all departments are on the

field of the process together and are active players on the project team.
2. Marketing and manufacturing are now integral parts of the product development process. But the PPP tended to be only an engineering or technical scheme.
3. The decision points or gates are also cross-functional in second generation stage-gate process. In first generation one, the project received the needed support and resources from one function and it wasn't in need of taking commitment of other functions. Today's system sees cross-functional decision making, where the senior managers who have needed resources come together at a meeting and together decide on and commit to a project.
4. Today's stage-gate projects take the process as a whole from idea to launch of the new product and do not take the middle stage of the process as in the first generation systems.
5. Second generation stage-gate systems give more importance to the pre-development work than the first generation systems do.
6. Second generation systems create a more strong market orientation. Because the customer needs are very important at this system.
7. Second generation systems are undertaken the activities concurrently and in an elapsed period of time. But in first generation system the activities were done in sequence.

Another study about second generation stage-gate process represents three key components to implementation [87].
1. This system manages the organization's expectations of and commitment to the new product development process.
2. This stage-gate process also develops the flexibility and adaptability as a balance to the discipline of the process.
3. The frequent and productive dialogue between cross-functional teams and cross-functional management is managed by this second generation stage-gate process.

So a summary can be done to see the differences between the first and second generation stage-gate process systems as follow [27, 28]:
1. Much better cross-functional teams.
2. Less recycling and rework
3. Earlier detection of failures.
4. Better launch.
5. Shorter elapsed *time due to better homework, more functional inputs, sharper market and product definition.*

According to Cooper [27, 28], there are also problems of the second generation stage-gate process:
1. Projects must wait at each of the gate until all the tasks have been completed. This creates delays and the cost of these delays can be expensive for the companies.
2. Stage-gate systems require the all activities of the stage be finished before passing to another. Overlapping of the stages is not possible. But today the speed is very important for the companies and according to the speed, there must be overlapping of the stages in the model.
3. Second generation stage-gate process system has little attention about the resource allocation problem.
4. This system has detailed procedures about the activities in the stages. But much detailed procedures can make the members of the companies blind about thinking more of the product.
5. Some managers in this system can see the processes as in bureaucratic way and so want more paperwork, more meetings.

If the problems are like those with second generation stage-gate process system then the solution for this problem is the third generation new product process. This new stage-gate process is particular emphasis on efficiency.

As Cooper [27, 28] states that the third-generation stage-gate process represents a balance between the need for action and complete information to provide moving quickly. The four fundamentals of this process system are as follows:
1. **Fluidity:** It is fluid and adaptable. It provides these features by overlapping and fluid the stages for greater speed. For example, some activities normally done in the next stage will begin before the current stage is completed or long-time activities might be brought from one stage to an earlier stage.
2. **Fuzzy Gates:** Third generate stage-gate process system provides Go decisions which are dependant on the situation. It means these Go decisions are not necessary absolute, rather they are conditional and situational.
3. **Focused:** This system builds prioritization methods which look at the whole project. It also focuses resources of the new product development process.
4. **Flexible:** It is so flexible system. Because each project is unique and has its own way through the process. The rule here is that not to see all gates as must be passed through nor are all stages essential. It is obvious that new product process is essentially a risk management process and so:
    a. The risk level
    b. The uncertainty
    c. The need for information defines what the steps need to be done and which can be left out.

With the third generation stage-gate process system much more freedom are given to project leaders, teams and senior mangers. With freedom they also take more risk about the decisions of course. But this new stage-gate process is more sophisticated, sensitive, delicate and requiring more experienced, professional management approach in the companies.

As Cooper [27, 28] stated second generation stage-gate systems created improvements in the effectiveness of the process like higher success rates, tomorrow's process will provide more efficiency by speeding up the process and the better focus. The system will be a smart system. This system

will also combine the conditional or situational gate decisions with a fluid and overlapping stages. So the next stage will begin before the previous one has ended. And a final advantage of this system is the shift and clouding of the decision making roles. With more flexibility decision-making authority will shift away from senior management to the team and the leader of the team. This is consistent with the concept of a self-managed team understanding.

1. Eleven guide-lines for good implementation of the stage-gate process

O'Connor [87] states a guideline to provide a basis for effective implementation of a Stage-gate process in the companies or any organizational setting. The guidelines consist of three main group and eleven activities under these groups. These guide-lines are expressed as follows:

Group 1: Instilling the Process

This group of guidelines tries to establish the need for the process and to secure commitment and dedication. The purpose of this group of guidelines is to help generate the motive and energy for implementation. The activities in this group can be summarized as below:

a) To make attempts to establish, communicate and gain acceptance for a new product development process. Firstly, to do this the current gains and the loses of the process for the organization must be evaluated. To do this, current practices of the other companies and benchmarking rules can be applied. It is also so important to present and to communicate the information in a motivating way throughout the organization.
b) To secure senior management commitment and involvement in the process. It is very important point for the process success. Because the earlier contribution of the top management to the process means the greater the organization will embrace the process. If top management's commitment is not managed properly then the guideline 1 must be reconsidered.
c) The total new product development process must be dedicated to specific personnel which have their own budget and are responsible for design and the implementation of the whole NPD process. Their role will be to establish the process and to guide and influence the organization embracing it.

Group 2: Preparing the Process

Second group of guidelines focuses on designing a blueprint for the process, addressing key organizational issues and crafting a realistic path forward. To match the process with the ability of the organization is the main purpose of this group of guidelines:

a) There must be a design which will provide logical and flexible process based on a Stage-gate workflow. This workflow matches the nature of the organization's products, technologies and culture of the organization.
b) There must be a focus on multifunctional teams and the need for concurrent activities by team members. To make clear about deciding when teams are needed and when they are not is also a very important point.
c) Some tools should be used in the process to support it. These tools can be reference manuals, pocket guides, team building activities, electronic communications, and project management software to support the process.
d) It must be addressed the issues, challenges and impediments of implementation concurrently. It must also be emphasized the business unit strategy and values.

Group 3: Diffusing the Process

a) The positioning of the stage-gate process throughout the organization is very important. If the people in the company does some things different from the old practices then it is understood that this process had been effective for the organizational change.
b) This stage-gate process should manage the expectations and perceptions of the management and the organization for the new product development process.
c) This process must link the efforts directly to the total quality management. So there must be found some ways to measure and improve the quality of work effort and the effectiveness of the multifunctional integration in both activities and decision making.
d) The implementation of the process must be adapted to the organizational requirements of the company. To seek ideas and opinions of all contributors will prevent the bureaucracy in the process.

E. Generic Models For NPD Process

Many researchers have made generic model definitions for the new product development process for years. For example, Phillips et al. [92] have compared six different companies' stage-gate process approaches to the product development process under a four-staged framework as follows:

Stage 1: Preliminary Concept Development
Stage 2: Design and Development
Stage 3: Validation
Stage 4: In Service Product Support.

Cooper [27, 28] also have made many researches about new product development process model and identified four main stages in the model as:

Stage 1: Preliminary Investigation
Stage 2: Build Business Case
Stage 3: Development
Stage 4: Test and Validate

Another research which is made by O'Connor [87] is defined five main stages for the development process as follows:
Stage 1: Preliminary Assessment
Stage 2: Detailed Investigation
Stage 3: Development
Stage 4: Testing and Validation
Stage 5: Full Production and Market Launch

Peters et al. [89] have identified the model as three main stages as follows:
Stage 1: Pre-design and Pre-development
Stage 2: Design and Development Process
Stage 3: Post-design Development

Nijssen and Lieshout [86] have identified the main stages of the new product development methods as below:
Stage 1: Idea Generation
Stage 2: Product Optimization
Stage 3: Marketing-mix Optimization
Stage 4: Prediction

All these researches state that all the models have some similarities about their main stages for new product development process. It is clear that the differences between the models are not in the stages but the phases under them in fact. Researches show that these phases under the stages change four to ten. But it is so clear that the new product development process begins with product definition activity under idea generation phase.

F. Importance of the Quality at New Product Development Process

The economic success of manufacturing companies depends on their ability to identify the needs of customers and quickly translate these into high quality products that can be produced at low cost to satisfy these needs [42]. It is so clear that creating a product in high quality that will satisfy customer needs should be higher priority for the company's competitive position in the markets [115].

As Cooper and Keinschmidth [23] stated, the quality is very important term for the success of new products in the markets because of its influence on firm reputation and customer loyalty, the relative attractiveness of products to customers and ultimately product market share and profitability (Hessler and Chakrabarti [126]).

In the same article of Hessler and Chakrabarti [126], Crawford and Dobyns states that product quality has come to drive the overall competitiveness of firms as well as the standard living of societies in general. Because eight of ten buyers ranked quality as more important than price when purchasing a product.

The quality of a new product can be increased, if the criteria assigned to development projects are consistent with the goal of high quality. The conditions of high quality in a new product development process can be stated as follows (Hessler and Chakrabarti [126]):

1. The product quality is increased if quality enhancement is relatively important to top management of the company.
2. If the development process concepts and goals are defined clearly and the ambiguity is reduced then the product quality is increased.
3. If the organizational culture reduces the mistakes about the project then the product quality is increased.
4. If the reward system is applied in the company and some facilities about problem solving and project learning among the members of the company are done through the company then the product quality is increased.

G. Idea Generation Of New Products

Peters et al. [89] define the idea of the new product as the phase in which a business opportunity is identified and evaluated with respect to the general requirements of the company.

Perhaps it is the most difficult step in the process because the remaining steps can not take place without ideas to progress. To become a successful developer of new products is related firstly to become a successful developer of new ideas [108].

Idea phase contains some steps to be successful as follows [89]:

1. Identification: This step allows business opportunities to be identified firstly in idea generation.
2. Collation: This is to make clear the way of to bring business opportunities to light within the companies.
3. Prioritization: The rating of the opportunity in the company to turn into viable business proposition.
4. Idea Introduction: After consideration of the idea seriously the more detailed feasibility studies need to be in place.

1. Resources of the ideas for new products

There are some resources for the new product ideas in the company and these resources can be sated as follows [108]:

a) Technical knowledge within the company
b) Bright ideas within the company
c) Sales department suggestions
d) Competitors' activities
e) Customer Suggestions
f) Problems from customer operations
g) Other internal researches
h) Supplier's innovations
i) Problems which arise in the company's operation
j) Academic research
k) Market research/ market requirements.

Kelly and Storey [67] states the resources for the new product idea in new product development process as below:

a) From formal and informal search procedures of the company,
b) They may involve the organization in creating the means of delivering service product,
c) They may also involve the organization in obtaining the rights to the service product.

2. Factors that will affect idea of NPD process significantly

Some factors which will affect the new product development idea must also be known before passing to model and these factors are explained as follows [7]:

a) Structural Complexity
b) Functional Complexity
c) Product Newness
d) Product Complexity
e) Commercial Constraints

a) Structural Complexity

Product's complexity is influenced by the five major categories as follows:

(1) Number of Components;
(2) Number of process stages;
(3) Degree of connectivity;
(4) Number of technologies;
(5) Technological difficulty of design, manufacture, assembly and the test.

b) Functional Complexity

This is directly related to define the content and structure of the product and so more difficult work. There are also some factors which influence the functional complexity of a product as below:

(1) Number of functions criteria. If there are more functions about the product to be performed so there is also more complexity as functional for this product.
(2) Degree of specificity on the performance criteria. Specificity is known as increasing the complexity of development.
(3) Appearance was seen to add the complexity of development where the customer is unable to express articulate his or her desires. In the appearance of a product, the customer evaluates its safety, style, comfort, flour and taste, smell, texture, handle features.

c) Product Newness

Newness is also a factor in increasing the complexity for development. As newness increased it was perceived to make a development more complex, difficult and demanding. On some dimensions, newness could be defined objectively especially in the marketplace and customer-based measures.

d) Project Complexity

This measure for the complexity of the project and relates to total time scale and personnel required. The specific factors which influence the project complexity are:

(1) Number of working person days.
(2) Number of disciplines involved.
(3) Number of people involved in the development of new product within the company.
(4) Number of design personnel involved in the project.
(5) Number of people involved in the project external to the company.

e) Commercial Constraints

These are the constraints which exist within the project framework. The factors of commercial constraints are as below and as these constraints increased in both intensity and number, the complexity of development increases:

(1) Quality
(2) Development Cost
(3) Development Time
(4) Adverse Legislation
(5) Competition
(6) Product life
(7) Product Cost

3. Importance of concurrent engineering activities from idea stage

A high level of team work and the integration of business functions in the development process is very important. The essential need for this important activity is done by an essential component which is named as "concurrent engineering". Concurrent engineering (CE) offers companies the opportunity to reduce the time it takes to develop new products. CE encourages many diverse inputs to the development process at the early stages and provides the design of new products tend to become everyone's business [94].

Concurrent engineering is directly related to multi-functional teams understanding in the company. Poolton and Barclay [94] also state that the activities for the integration of whole company members, suppliers, customers into development stages at earlier stages will provide the installation of multi-functional teams, project based reporting and the adoption of formal methods like quality function deployment in the process.

Obstacles and short-term pressures will continue to affect the new product development process. But a real attention on the concurrent engineering applications in the process will provide achieving high performance and gain profits from these barriers [84].

To apply concurrent engineering is related to understand the key features of concurrency. The key features for concurrency in a new product development process can be listed as follows [78]:

a) Manufacturing and engineering departments should work together in process.

b) Multi-functional teamwork is an urgent need for the process.
c) Team should have collective responsibility.
d) To replace the sequential activities in the development process with concurrent activities.
e) Shifting planning activity to the front end of the project.
f) Leadership is ver important at concurrent activities.
g) To get the decisions in the company about new product with consensus.
h) Obtaining customer input is very important for these activities.

4. Importance of early definition and organizational structure at the idea generation phase

Firms will have positive effects both on profitability and reduced time to market if they make excellent product definition before the full development program. This definition includes [30]:

a) Specification of the target market which describes the intended users.
b) Description of the product concepts
c) Definition of the positioning strategy.
d) A list about product's features, attributes, requirements and specification. There should be prioritized as "must have" versus "would like to have".

After definition the organizational structure is very important in new product development process too. That is because product innovation can be managed with team effort. So a multidisciplinary, multifunctional efforts are important and are directly related to good organizational design The key elements for good organizational design are as follows [30]:

a) Projects that are organized as multifunctional teams. Such teams provide members for the process from R&D, engineering, marketing, sales, operations and so on.
b) Projects that the team members are not just representatives of their respective functions but also protect their functional capabilities.
c) Projects that the team is dedicated and focused.
d) Projects that the different team members are in close contact with each other in the process.
e) Projects which give responsibility to all teams in the process from beginning to the end.
f) Projects that there is a strong project leader in authority who leads and drives the project.
g) Projects which top management strongly supports all activities in the new product development process.

Factors for product definition of the new product development process

Product definition is the beginning to the new product development process. It is the most important activity of the first stage of the process. The first stage of the process is the idea generation of the process and it begins with the exact product definition.

The factors for defining a strong new product definition with their thinking questions are stated as follows [10];

a) Strategic Alignment
Managers must think about how this project contributes to the business unit's strategic objectives firstly.

b) Users and Customers Need
The market segment for this new product must be thought firstly. Then it should be thought that whether the team in the company can solve the problems of this new product to be successful in the development process.

c) Compliance Issues
The team has to identify all the relevant compliance issues that the new product must adhere to, including manufacturing recycling issues.

d) Competitive Analysis
The team must identify the competitors' situations about the product. It must thoroughly identify the weaknesses and strengthens of them about developing this product.

e) Product Positioning
It must be defined whether this new product solve the customers' problems better than the competitors' ones.

f) Project Priorities
The priorities like cost, date or market release for new product development process must be identified in the organization.

g) Risk Management
The capability of the project team about taking risks in R&D, marketing and manufacturing must be evaluated exactly.

h) Market Channels
The market channels required to be successful in this business should be established for market release time.

i) Management Leadership
Upper management have to know about the project, support the efforts about it and provide the team guidance in making decisions about new product.

j) Resource Availability
The staffing needs and the resources for the new product must be examined and their evaluation about meeting the goals of the project have to be made.

k) Dependency Management
All internal and external strategic dependencies are established and controlled whether there will be integration or schedule problems about them.

5. Customer characteristics to identify the idea generation of NPD

There are some customer characteristics which will give a way for the predevelopment activities in NPD process. These characteristics can be stated as follows [50]:

a) Technically attractive customers that are innovative and have strong know-how basis.
b) Customer's financial attractiveness relates to their representatively of the target market and their reputation within the market.
c) The closeness relationship between the local company and the customer.
d) The lead user characteristics are relevant by the interviewees.

6. New product development management from the idea generation

Managing human interactions and the transfer of technology and ideas among individuals and functional groups can be the challenging aspects of new product development. There will be problems among the different departments in the development process. To solve these problems, to make decisions, will be the tasks of an effective leader in the process. Effective leadership also will make human interactions more productive, facilitating the progress of the ideas across the organization [59].

Increased interest in the dynamic structure of new product development has given many companies to turn away from traditional information and processing view and adopt new development models into their organizations. The new development models require a strong management role in establishing the foundation of knowledge creation during the new product development process [106].

The role of top management is very important in the process. Cooper [30] states that top managers in the companies must be a facilitator for the process not to be an actor. According to him top management's role in NPD can be stated as follows:

a) To provide the necessary product development resources and to keep the commitment for the process.
b) To decide for a new product development strategy by defining the new product goals in it.

Leading companies show six characteristics in managing their new product development processes. These characteristics are the pieces of a whole. The characteristics can produce a powerful set of dynamics that will make differences [111]:

a) **Built-in Instability:** Top management has a role about giving a broad goal or generic strategic direction to the teams in the development process. Top management also creates motivation in the process by giving great freedom to the project team to carry out the project for the company. The creative will be created by this method in the company.
b) **Self-organizing Project Teams:** The project team begins to operate like a new company if the teams are established as self-organizing. So the will take initiatives and risks and develops an independent ideas for the process. The team begins to create its own concept for the new product development process.
c) **Overlapping Development Phases:** The self-organizing character of the team produces a unique dynamic or rhythm. The project members start the process at different times but they all must work synchronizing their pace to meet deadlines. Each member soon begins to share knowledge about market place and the technical community.
d) Finally, the team begins to work as a unit. At the same point the individual and the team will be a whole. Because from now on the individual's rhythm and the group's rhythm begin to overlap, creating a whole new pulse which will serve as the driving force and moves the team forward.
e) **Multi-learning:** By working as a team, team members will have broad knowledge and skills which help them create a versatile team capable of solving the problems fast.
f) Such learning will be done in two dimensions: across multiple levels like individual, group and corporate and across multiple functions. All of these two dimensions of learning is considered as multi-learning.
g) **Subtle Control:** As stated above that project teams are largely on their own in the new product development process, they are not uncontrolled indeed. Management establishes some check points to prevent instability, ambiguity and problems in the process.
h) Management avoids setting a rigid control on the teams which will also prevent the creativity. Instead, the control is self-control and control by love which is collectively called as subtle control.
i) **Transfer of Learning:** It will be so important of the transfer of the information between the departments throughout the organization. So there is another kind of learning in the company with this tool. Transfer of learning to subsequent new product development projects or to other divisions in the organization takes place regularly.

(a) Principles of successful new product development management

Souder [107] states ten principles for the management of the new product development processes successfully:

(1) To develop a product with a desired success rate is related of being the product special for the customers. When the products are designed as

special they also require special management qualities too.

(2) Success in the new product development is not a smooth process and so a great patience is needed to catch the success.
(3) To try controlling the new product development process with traditional budget techniques is not possible. The effective financial control systems must be set up for the process in the organization.
(4) It must be taken a systematic approach to selection of the best projects for new products.
(5) The cost is very important for the companies. So the most important cost-effective method should be selected for managing new product development process.
(6) Sometimes there can be problems especially between R&D and marketing groups. These problems can be from lack of understanding, lack of appreciation, lack of communication and distrust between these two departments. All these problems severely constrain the success of new product development success. Managers must take several steps to eliminate and avoid these problems. So the disharmony between these two groups will be eliminated.
(7) To analyze the customer's level of product sophistication and the product developer's technical level for it is very important in the innovations. Because sometime customers can not understand fully their own needs on products and so can not translate these needs into specifications. Also company can not understand the specifications of the customers but try to develop the product.
(8) Managers must learn to measure and understand two dimensions of technology: accessibility and state of art. An inaccessible technology is disembodied know-how that must be synthesized and fully elaborated before the organizations can develop useful new products from it. In a low state of the art technology the organization must upgrade its know-how before it can make use of technology.
(9) Companies must not try to use classical organization structure approaches with innovations.
(10) Internal technology transfer like transfer of ideas and flow of technologies between departments is very important and managers must pay close attention for it.

(b) Guidelines for managers to achieve high performance

There are determinants of new product performance. These determinants proposed usually involve some combination of strategic, development process, organizational and market environment factors as drivers of new product performance [82].

Managers also need some guidelines about rising of the new product performance according to these determinants. The guidelines stated below give four necessary rules for the managers to be applied in new product development process [8]:

(1) Try to generate new product performance objectives.
(2) Assess whether performance objectives in new product have been met.
(3) Determine what has contributed to the performance level.
(4) Develop rewards among the members of the organization to encourage achievement of objectives.

7. The steps of new product strategy at the idea generation phase

Undertaking a product development activity without a strategy is like running a war without a military strategy. There is no direction and the results are often highly unsatisfactory if the there is no strategy for development activities [29].

There are three important steps to create a product strategy which will give a regular way to new product development process [110]:

a) **Creating and Using a Map of the Company's New Product Activity:** These maps help to define a stream of products and to force the company to make decisions about new projects for products. The important thing here is the effective use of these maps with the help of management tools.
b) **To Try Building Product Strategy Without Holes:** Companies should understand who are buying their products and why. So they would fully understand the needs of their customers about new products and so make judgments about the holes in the markets. Then they will agree about the ways of protecting themselves from those gaps. Maybe they make their existing offerings about products more attractive or add new features to the new products or run some promotional activities about the products.
c) **Getting Good Market Information:** To pass to the product definition and make effective definition about product is directly related to the demands in the markets about it. Open-ended conversations with the customers will provide this information for the companies. With this information which is taken from customers, managers will think the technical capability of the company to manage this type of product, make some predictions about the progress and updates the applications.

8. The importance of project organization for idea generation

For time and effective execution of the product development process the organizational characteristics of the company are very important and there must be some practices about them before definition of the product.

There are three best practices relating to project organization as follows [110];

a) **Creating New Business Units for New Markets:** When a company intends to develop a new product, to make a leap with this product in the competitive market environment it will probably need to design a completely new product system like to address the new users of it. The easy way of solving this problem is to create new business units of the company in the new markets. Of course this method will cause a change in the project organization too.
b) **Knowing How to Choose the Optimum Number of Members for the Product Definition Process:** To assign too many people to product definition teams can delay the definition process and the results about this process. The important thing here is not the number of the people in the definition stage but adequate number of the professional members which have mix of skills and experience about product definition.
c) **Matching Resources During New Product Development Process:** Cycle mismatch problem is very important for the companies in NPD process. This problem creates the trouble of using engineers and marketing professionals regularly for new products. Because sometimes in the product development process, there is relative burden on engineers and marketing professionals. These relative burdens may lose the opportunity to begin work on new product enhancements for the company. At the launch phase engineers must wait for busy marketing professionals to finish the new product launch. Because only after this activity they can help define of others.

The correct this imbalance; companies can give a scheduled break. During this break the managing team identifies markets that would be affected by the new product, to initiate the development of derivatives to fill potentially vulnerable areas and assign key people for engineering and marketing in the development task.

The organization types for the companies

To provide commitment in the whole company and manage the development process with success, the organization type used for the development process in the company gains much importance. There are three main organization types according to Ulusoy et al.[118]:

1) **Functional Organization Type:** The members of the company are divided as functional sections-including marketing, R&D, production- according to their abilities, functions and expert areas in the company. The features of this organization type can be stated as follows:
   (a) There is no multi-functional team-work in this organization type.
   (b) Every department executes its own work about development. So the sharing, creating of information through company is impossible in this organization type.
   (c) Every department sees another department as a rival in this process.
   (d) The important thing for the departments is the success of their own department not the company as a whole.
   (e) The aim of the departments is "to do the work" not "to do the better".

2) **Matrix Organization Type:** This can be stated as the mix of the project organization type and functional organization type. There are project teams in the process and they report either to their project manager or to functional department managers. Andersen et al. [2] state the features of this organization types as follows:
   (a) It provides better structure for decision-making and responsibility.
   (b) It shortens the lines of communication between the departments and so provides better communication.
   (c) The company will have more flexible organization structure which is better adjusted to the problem and the people who will work on it.
   (d) Better use of resources can be provided with this organization type.

3) **Project Organization:** Company establishes a structure which is focused on to project teams. The members of the team are directly connected to one project managers. They take all the works from this manager. [118]. This type of organization can make the some difficulties about the top manager's control in the companies.

Larson and Gobeli [73] states some organization types which show some similarities to the classification that is done above as follows:

a. **The Functional Organization:** The project is divided into parts and assigned to functional groups. The project is co-ordinate by functional and upper levels of management.
b. **The Functional Matrix:** A person is actually designated to oversee the project across different functional areas. This person has limited authority over functional people involved in the project. The functional managers are the main responsibility for their department's specific task in the project.
c. **The Balanced Matrix:** A person is designated to oversee the project in the equal basis with functional managers. This person and managers of different functional departments plan and coordinate the project.
d. **The Project Matrix:** A manager is assigned to oversee the project and is responsible for the completion of the project. The functional manager's

involvement is limited to assigning personnel as needed and providing advisory expertise.

e. **The project Team:** A project team composed of personnel from several functions about project at the leader of a project team is assigned for the execution of project. There is no functional manager involvement.

9. Differences in development process activities by project task complexity

New product development projects can be classified as to their complexities and about their cycle times [21]:

a) Short-cycle simple projects which make only minor modification to existing products.
b) Short-cycle complex projects which make major modifications and new to the world projects.
c) Long cycle projects are traditional old process techniques used in NPD process.

10. Preliminary assessment activities for idea generation

After describing the idea and definition of the new product then the preliminary assessment activities of the idea should be done. One of these activities is the screening process. It can be a single activity or multi-stage procedure, and it can utilize quantitative or qualitative screening criteria [67].

Cooper [26] defines the screening as the initial GO/NO GO decision of a new product project.

Again in his another article, Cooper [30] defines the screening as the decision to get into the idea in the development process.

Cooper [26] states some variables about screening phase to be evaluated by the company in this idea stage as follows:

a) Resource compatibility of the company,
b) The viability of project characteristics to the company,
c) Newness of the idea to the company's capabilities,
d) Nature of product for the company,
e) Nature of market for this new product.

Portfolio management: an effective tool for resource compatibility

Portfolio management is about resource allocation in the companies and it shows the way about how you will spend your scarce engineering, R&D, and marketing resources. Resource allocation is also a problem that must be solved in the idea screening phase with this technique. That is because it is so critic to manage the business's new product and technology objectives [24].

The portfolio selection models are highly mathematical and employed techniques such as linear, dynamic, and integer programming. Cooper et al. [24] states the methods as:

1) **Financial Models and Financial Indices:** The methods like net present value (NPV), internal rate of return (IRR) and payback methods are some examples for these methods.
2) **Probabilistic Financial Methods:** These include Monte Carlo simulation and decision trees methods.
3) **Options Pricing Theory:** This new method treats each stage of the new product much like purchasing an option on a future investment.
4) **Strategic Approaches:** Selection of portfolio in the companies is related to business strategy. The business strategy decides the resource allocation in the companies. Strategic considerations affect the decision about R&D and new product activities.
5) **Scoring Models and Checklists:** Projects are scored on a variety qualitative questions and rated according to this data.
6) **Analytic Hierarchy Process:** Comparison of both project and criteria is made with these tools. Analytic Hierarchy Process (AHP) allows the decision makers to visually structure a complex problem in the form of a hierarchy having at least two levels as objectives and activities. Each factor or alternative can be identified and evaluated with respect to other related factors [76].
7) **Behavioral Approaches:** The tools for bringing managers to a consensus in terms of which projects to undertake and include methods such as Delphi and Q-Sort. These are very important tools for qualitative information about project.
8) **Mapping Approaches or Bubble Diagrams:** The tools for allocation resources across the business units in a corporation like Boston consulting group portfolio models and the GE/Mc Kinsey model.

H. Concept Writing of the New Product

Rosenau et al. [96] gives the definitions about concept of idea in their book as: A clearly written and possibly visual description of a new product idea which includes its primary features and customer benefits is called as concept. The act of generalization of the new product idea is concept generation.

A research approach that evaluates how specific product benefits to customers contribute to concept's overall appeal is concept optimization and the results from concept optimization are used to select from the options investigated to construct the most appealing concept from the customer's perspective.

Casto [18] also states the concept definition as the activities necessary to translate the organization's strategic plan into strategic project plans. Concept work on a development process will begin when a development team is assigned and authorized to begin the work of development. Concept work builds a bridge between business planning functions of the organization and the development activities.

According to Casto [18], concept definition will reduce the need for time spent on individual learning curves as the project moves from concept to design and minimize the amount of "second guessing" of the work in the concept phase.

Concept definition requires a macro view to both the organization and the world around it. It is very critical for the

people in the concept definition task to maintain an objective viewpoint and refrain from taking personal ownership of any proposal. Concept definition also requires the broadest of perspective and the ability to conceptualize with the added dimension of time [18].

In concept definition, using an understandable language for the customers is very important and needed persons with this ability in the company. If the customers understand the concept well, then they can evaluate the degree of the new product whether provides their requirements of them completely or not. The problems will be solved by the way without passing to development of the new product [96].

1. Concept testing

Concept testing is an important method used in the concept stage. It is the process by which a concept statement is presented to customers for their reactions for the new product in the market. These reactions are used to estimate the value of the concept of the new product or to make changes in the concept of the new product according to its potential sales value [96].

Concept testing is needed to determine customer requirements and assess the customer acceptance of the new product idea. By concept testing firms will develop a new product that people want to buy. Concept testing also seems linked to the technological orientation of the companies. The companies will determine whether or not the technology developed can be translated effectively into a workable product whish meets customer requirements and offers perceived customer value [8].

Concept tests must also use various data collection and aggregation methods to get meaningful results [41].

2. Concept feasibility studies

There must be done some feasibility studies about new product according to the information from the idea generation and preliminary assessment phase. The information taken from this phase will be converted into business opportunity in the concept feasibility studies. That is because the information will fulfill the internal and external requirements of the proposed idea. Different possible solutions and necessary activities will be also clear with these feasibility studies [89].

The needed feasibility studies in the concept phase of the new product development process are stated by Peters et al [89] as follows:

a) There must be done assessment of all aspects of opportunity from technical capabilities of the company.
b) Costing and budgeting facilities about product must be finished.
c) The evaluation of both human and production resources about this product must be executed.
d) Time scales about new product must be defined.
e) Post-company requirements and the capabilities of the company for them about product must be already thought.

3. Niche marketing and product variety management in concept writing stage

It is clear that the customers in the society have variety minds. Customers' preferences are often heterogeneous and every customer looks for variety at products in his/her acquisitions [113].

The product variety will cause complexity results for the companies in new product development activities actually. This complexity results from five main resources [95];

a) Inherent product complexity,
b) Process complexity,
c) Team co-operation and communication complexity,
d) Computer and network complexity,
e) Specifications including international regulations and safety.

Product variety management

According to Da Silveira [35], managing the product variety in the companies can be provided by applying strategic and operational flexibility rules in the development process. The Rules of strategic and operational flexibility for product variety management can be explained with these rules as follows [35]:

a) Strategic Flexibility Rules

(1) **Product flexibility**: the ability to introduce or modify products economically.
(2) **Mix flexibility**: the ability changing ability of products made within a period.
(3) **Production flexibility**: the ability to produce a range of part types economically.
(4) **Volume flexibility**: the ability to operate different product volumes economically.
(5) **Expansion flexibility**: the ability to build *and expand the system's capacity*.

b) Operational Flexibility

(1) **Delivery flexibility**: the ability to change delivery times.
(2) **Process flexibility**: the ability to produce with different process.
(3) **Programming flexibility**: the ability to operate unattended for a given time.
(4) **Routing flexibility**: the ability to process given parts using alternative routes.
(5) **Machine flexibility**: the ability to perform different operations efficiently.
(6) **Labor flexibility**: the labor's ability *to perform a wide range of tasks efficiently.*

The importance of niche markets in concept identification

In market led economies, it is important to determine the potential demand for the new products and then produce new

products for those demands. It is also essential to analyze the competitors' abilities to look for new market opportunities. This will help take some precautions about getting the new markets [114].

These potential demand markets are known as niche markets for the products. By differentiating products with product variety strategies and targeting specific customer groups, companies can take advantage in the competitive market environment [112].

Niche marketing is an approach which has been applied successfully by some companies in the world. Target marketing, focused or concentrated marketing are all used for niche marketing [34].

Dalgic and Leeuw [34] define niche marketing in the article as a method to meet customer needs through tailoring goods and services for small markets.

In the same article Kotler [71] states the following ways to specialize the niche marketing idea:

a) end-user specialization;
b) vertical-level specification;
c) customer-size specification;
d) geographic specification;
e) product or product-line specification;
f) product-feature specification;
g) job-shop specification;
h) quality/price specification;
i) service specification;
j) channel specification;

These are the key ideas to lead the companies to pursue niche markets. Niche marketing is concluded as positioning into small profitable homogenous market segments which are ignored or neglected before. So five essential elements for niche marketing are [34]:

a) Positioning;
b) Profitability;
c) Distinctive competencies;
d) Small market segments;
e) Adherence to the market segments.

Niche marketing for larger companies will mean new opportunities for healthy smaller markets, a new approach to the market, smaller profits per but more markets an easier defense method against the potential competitors and adaptation of structural internal organization in the company.

Companies follow this strategy for the following reasons:

a) To avoid competition with larger companies;
b) To enhance opportunity;
c) To survive.

There is a general checklist stated by Dalgic and Leeuw [34]. To prevent potential marketing mistakes at niche market applications:

a) Know your strengths and weaknesses, competitive advantages, traditional and regional characteristics of your company.
b) Get exact information about customers in niches.
c) Know the reasons of the customers' using of the competitors' products.
d) Develop present-day database techniques which will provide cheap and affective information in marketing.
e) Apply differentiation.
f) Avoid competing with your own products in the same market segment.
g) Create high entry barriers for competitors to prevent them building relationships with your customers.
h) Don't exceed your limit about niche numbers.
i) Link your niche marketing plans into corporate plan of the company.
j) Watch the market and respond to them in time.
k) Do not be static in this environment. Look for doing better always.
l) Do not stand to only one customer and try to increase the alternatives.

4. Quality function deployment technique in concept development

Concept development stage of the development process is also needed using quality function deployment technique (QFD). This is a method for helping the development teams about identifying and interpreting needs and requirements of the customers. This method can be applied to the customers in writing or by simple means [86].

Rosenau et al [96] also state the QFD as a structured method employing matrix analysis for linking what the market requires to how it will be managed in the development effort. When multi-functional teams in the company want to agree on how customer requirements affect the specifications of the new product, they use this technique. By this technique, the chance of omitting important design characteristics about new product will be eliminated by the multi-functional development teams of the company.

I. Development and design of the new product

Companies are in need of improving new techniques in the new product design and development process. Because customers want quality certificates as ISO 9000 series from the companies [109]. As many industries have matured, the importance of high-technology marketing will increase and customers will prefer high-tech market products [124].

So design and development phase of the new product is also very important for the companies. Companies must have an approach to adapt to the new principles and rules about design and development and this is managed as follows [54]:

1. Finding out the operating principles and rules of the new technology for design and development of the product.
2. Pointing out the effective parts of the system and production functions.

Product support which means various forms of assistance that companies offer customers to help them gain maximum

profit from the product must also be thought by the team in design and development phase. Because product support with activities like installation, customer training, maintenance and repair will be shaped in this phase according to technical and physical capabilities of the new product in this phase [64].

Design of a new product is very difficult work and needs systematic approaches to be successful. The steps of the design process are as follows [45]:

1. Understand the user needs;
2. Prepare the design input;
3. Think about design concept;
4. Make a conceptual design review;
5. Make some calculations on setting the design parameters;
6. Make preliminary design review of new product;
7. Check the detailed manufacturing specifications of both military and commercial customers.
8. Apply final design review of the new product;
9. Make the design output;
10. Finally present the product.

Cooper [28] states three important rules for design of a product:

1. Determine customer needs;
2. Do competitive analysis to see the competitors' situation;
3. Test and verify all assumptions about new product.

To define and rank of the critical and non critical design works according to the principles above will be the help of value engineering technique stated by Fang and Roperson, [45]. So this difficult process will be easier for the engineers in the companies.

1. The problems for new design process in the companies

There will be some problems in the company when some attempts about new design activities are done. That is because it calls change in attitudes and often organizational changes as well. But to create a new product with competitive power is directly related to implement some new design techniques in the development process. For solving the problem to know the problems for design process will be profitable. The problems can be stated as follows [81]:

a) Reluctance to change long-standing procedures by practitioners.
b) To develop team culture needs about change requires time.
c) The perception of the managers for the change.
d) Information gathering for applying the change in the organization can be seen as time consuming activity.
e) There can be resistance of engineers about involving themselves in marketing issues.

2. Recommendations About Managing Change in Design Process

Mill and Ion [81] also states about their experiences of change and the recommendations about solving these problems as follows:

a) Use dedicated teams.
b) Use a facilitator or champion to make things happen
c) Always gain management support for this change.
d) Impose changes slowly in the organization.
e) Let design be the change agent.
f) Don't make any claims which are not achievable in the change.

3. The Engineering Abilities for Development Process

There must be used technologically strong engineers for development and design of the new product. Engineers must have knowledge about the techniques of some tools about development and design phase. These tools are completely technological based and increase the speed and decrease the cost of development process. These tools are as follows [96] [109] [118]:

a) Computer assisted design which allows engineers to use computers for design work.
b) Computer enhanced creativity is a software that aids in the process of recording recalling and reconstructing ideas to speed up the development activities.
c) Value engineering analysis
d) Fault tree analysis
e) Process capability design
f) Risk analysis
g) Statistical experiment analysis
h) Value analysis

4. Conjoint analysis in development stage

Conjoint analysis must be done carefully for shaping the design and development activities of new product. Because this analysis provides information about how customers make trade-off among a small number of features and benefits. If these features and benefits are known well, then the activities in design and development phase will be conducted according to them and so more suitable new product will be designed and developed at the end for the customers. So the conjoint analysis technique must be known and applied professional by the companies at this stage of new product development process. This will also provide many specific advantages to the company in this competitive environment [96].

5. Using of R&D index and staffing ratios for development activities

R&D activities are crucial in order for a high-tech industry and these activities need large investment for companies [72]. R&D activities are risky by nature [3]. So the decisions about R&D activities must be taken carefully and effectiveness of R&D activities must be calculated in the activities.

To find the effectiveness of company's product development activities, a tool named as R&D index is used. Companies must focus on the effectiveness of their R&D investment instead of how much they invest.

This R&D index will provide the profit from new products to the investment in the new product development using the following single formula [80]:

Effective index =New product Revenue * (Net Profit % + R&D %) / R&D %

The index will measure the ratio of increased profits from new products divided by the investment in product development. When the index above 1.0 then it means the return from new products is running at a rate greater than the investment.

Another important tool for development actives is staffing ratios [48]. Staffing ratio is a tool for measuring the human capacity in development activities. It is clear that engineering department has the primary responsibility for developing new products. So there must be a metric for measuring the ratio between the number of engineers to the number of full time dedicated product development activities and this is measured by staffing ratios metric in the company. The staffing ratios metric can be formulized as follows:

Staffing ratio = Total engineers / Number of engineers dedicated to NPD

It is very important to think the best ratio for the product development activity here. It means managers must think about how many engineers should be dedicated for this type of new product development activity. A survey is made to find the accurate ratios for development activities with 1000 manufacturer of test equipment. The important point for using these staffing ratios is to see this survey information in the table which is given by Goldense [48] as a guideline and then to apply the best judgment for a given situation in the companies.

6. Experimental design technique in development and design stage

If some prerequisites are taken into account then the success with experimental design is provided conveniently. These prerequisites are [125]:

a) The need for understanding the customer requirements,
b) A carefully design for experiments,
c) Knowledge in the new product development's subject matter.

Experimental design is a tool to battle competitors by designing robust products, reducing time to market, improving quality and reliability and reducing life-cycle cost.

The application of experimental design provides these benefits for the companies [125]:

a) It significantly reduces the development time of new product;
b) It reduces expense of the new product development;
c) The performance of the new product will increase by experimental design;
d) It affects positive to the overall success of the new product development activity.
e) It is efficient tool for design and development stage in the new product development.

7. Factors in increasing development speed and efficiency of NPD process

Rorthwell [97] has been identified twenty four factors which increase the development speed and efficiency of NPD process. Some of them impact directly on speed, some on efficiency while others offer improvement along both dimensions:

a) A definite time-based strategy.
b) Top management commitment and support.
c) Adequate preparation about new product development for resources and commitment in the company.
d) Efficiency at the indirect development activities like project control, project administration, coordination.
e) Adopting a horizontal management style with increased decision making at lower levels.
f) Committed product champions and project leaders can play an important role in achieving both successful and faster new product development.
g) High quality product specification.
h) Use of integrated or cross-functional teams during development and prototyping (concurrent engineering).
i) A company can clearly speed up new product development if it cuts the corners in the process. This is called as commitment to across-the-board quality control.
j) To aim achieving speed in new product cycles with the help of smaller technological steps toward successive models.
k) Adopting the utilization of significant elements of earlier models in the most recent designs.
l) Product design which manages to combine the old with the new.
m) The designs in flexibility.
n) Economy in technology or to make robust design technologically as main principle for new product.
o) To establish close and early linkages with suppliers to reduce development costs and increase the development speed of the new product.
p) Creating a comprehensive, modern database on new component and material characteristics used in new product.
q) Involving leading-edge or technologically strong users in design and development activities.
r) Accessing external know-how in the company.
s) Using computers for efficient intro-firm communication and data sharing in company.
t) Use of computer aided design systems (CAD) along the production of new product in the company.
u) Use of fast prototype techniques.
v) Use of simulation modeling in place of prototypes.

w) Creating technology demonstrators as an input to simulation.
x) Use of expert systems like computer based product design and simulation techniques in the new product development process.

8. Prototyping of new product in development stage

Prototypes are required for evaluation of the product to provide feedback for design modification such as selection of design alternatives, engineering analysis, manufacturing planning and visualization of the product [116].

Companies always look at the ways for new product development process which make themselves different from their competitors. Techniques like total quality management, quality function development, concurrent engineering and prototyping helps to develop this differentiation for the companies [93].

Rosenau et al. [96] states the prototype as a physical model of new product concept. Prototypes are made according to the purpose as non working, functionally working, or both functionally working and aesthetically complete. Especially for military customers, the prototype testing is very important and so companies must work to develop prototypes which have the same features with real product.

It is so obvious that time, cost, risk, money are all important for the companies at product development process. So to apply some rapid prototype techniques are needed to reduce the time, cost and risks of the prototypes. Rapid prototype systems are capable of making highly accurate prototypes in a short time [116]. The aim of rapid prototype techniques is therefore [93]:

a) To do more
b) Better
c) Faster
d) With less

Firstly it must be known that rapid prototyping is not a simple activity for the companies. But the importance of these new technologies over the world can not be over estimated. Costs can be cut by 40-70 Per cent and time can be reduced 60-90 Per cent with these techniques. To ignore this relatively new, rapidly developing but well-proven technology, will result a serious loss of competitiveness in terms to market and the cost to market for the companies [121].

The main questions for rapid prototyping techniques

Companies must give answers to the questions about rapid prototyping techniques. These questions will help them to identifying the suitable rapid prototype techniques for their design and development activities. So these questions can be stated as follows [121]:

(1) How does the company make the case for the purchase of a system?
(2) Which system should the company buy?
(3) How does company gain maximum profit from this technique?

If the companies are especially involved on a regular basis in the design and manufacture of new products so there is no doubt for them about using rapid prototyping techniques.

9. Developing of the marketing plan at development phase

There must be a formal marketing planning in the companies. Many researches advocate the value of planning for a company's growth and development [11] [63] [79].

The most important thing in the marketing planning is to define the problem true at first. If the problem is not defined effectively at the beginning then the solutions will not respond to success in the companies. A guideline for effective marketing problem definition is as follows [17] [63];

a) Put the problem at the start of marketing research process.
b) Follow symptom-problem-decision progression. Here symptom means a condition which indicates the presence of a problem.
c) Conduct exploratory research before defining the problem.
d) Consider the different information sources and types.
e) Allow creativity through the organization to help problem search and definition.
f) Combine the inputs of the manager and the researcher.

After defining the marketing problem, there are also many barriers for successful marketing planning and these are stated in Hill et al. [53]. In the same article the competencies for these barriers are explained, too. The barriers and the competencies for them can be listed as follows:

a) There is confusion between marketing and tactics in the companies for marketing planning. This can be solved by judgment, knowledge and vision in the companies. Judgment means to develop ability in gathering disparate pieces of often incomplete information and making effective choices. Knowledge is to transfer of marketing skills with effective communication in the company. Vision refers to determine how aims and objectives will be realized through action plans and using the scarce resources.
b) There is an understanding for isolation of marketing function from business operations in the companies. The competencies for this barrier are knowledge, vision and commitment which will provide the members of the whole company to commit the value and importance of the planning process.
c) The confusion between marketing and marketing concept. This barrier can be overwhelmed by knowledge, judgment, appropriate communication channels through the organization and the ability of applying analytical skills in the companies.

d) Common organizational structures along the functional lines in the companies. The competencies for this barrier are communication ability, and organizational ability. Organizational ability refers to the ability to conduct and manage resources to fully maximize the value of opportunities in the market place.
e) Lack of skills in-depth analysis in the companies. This barrier can be overwhelmed with analytical ability, knowledge and vision.
f) There is confusion between process and output and this barrier can be solved by knowledge, judgment and analytical abilities sin the companies.
g) Lack of core marketing management knowledge and skills can be overwhelmed with knowledge.
h) There is lack of disciplined, systematic approach to marketing planning. The abilities for this barrier are analytical ability, vision, commitment, and knowledge.
i) There is need to prioritize objectives in the company. The competencies for this barrier are effective leadership abilities, vision, commitment, judgment, communication and organizational abilities in the companies.
j) There is need for more appropriate marketing and the competencies for this barrier are organizational and communication abilities, vision, knowledge and effective leadership features in the companies.

After passing the barriers about management planning, the results of concept stage are shaped into the marketing plan. The market selection, product positioning and product strategy are finished at concept stage and are shaped in the marketing plan. At the development stage of the new product, the supporting elements of the marketing mix like pricing, distribution, advertising, sales force strategy and services are decided and they are also shaped in the marketing plan [31].

The market selection is concerned with improving the mix of target markets and how chosen markets are best served. The purpose of market selection is to identify better potential markets and better ways to serve target markets. So identification is the first step for market selection [60].

Product positioning refers to the choice of target market segment which describes the customers and has three sub-components as follows [12]:
a) Customer Targets;
b) Competitor Targets;
c) Competitive Advantage.

The selection of customer targets highlights the critical role of market segmentation in the marketing planning. Segmentation provides the sub-division of a larger market into smaller parts and collects the subsets of customers with similar needs. It enables the company to isolate and to target specific markets.

The selection of competitor targets, should hinge around the evaluation of competitors in the light of the company's strengths and weaknesses and ability to compete. This is needed a careful analysis of the competition.

Competitive advantage will distinguish the company's offer those of its competitors in the segment. The essential factors when developing the competitive advantage are that it must be based on something of value to the customer and it must be sustainable.

After defining the positioning strategy the main elements of the marketing mix must be known by the companies. These elements are grouped under the four main parts and can be stated as follows:
a) Product: It must be defined the quality degree of the product, the features of it, the name of the product, the packaging styles of the product, the services and guarantees conditions for the product.
b) Price: The list price is defined, the allowances, the credit conditions and specials of the product about price is made clear.
c) Promotion: The advertising activities, the conditions of the personal selling. The situations of sales promotion, the public relations are defined under this main group.
d) Place: The situation of the distributors and retailers, the locations for the product, the inventory conditions and transportation conditions of the product are defined.

J. Testing and validation of new product

After design and development of new product and making prototype of the new product, the studies for testing and validation activities must be executed.

Prototype testing are activities for understanding the new product meets the specifications of both military and commercial customers. This testing method is used in both in-home and with customers [31].

1. Testing and validation methods for the companies

The new dual-use product prototype can be tested by using in-home testing methods. Home testing is an approach that has a number of customers test a new product at home for a certain period of time. Afterwards the evaluations are taken from them and made discussions for them in the company's development departments [86]. For dual-use products when the prototypes are finished, these can be given to the both military and commercial customers and the results of the applications can be taken as information for the new product.

Labs testing which are applied in the companies are also important methods. As Rosenau et al [96] states the alpha testing method will be used for testing. Alpha test method is aimed to evaluate the product features in-house testing to find the most obvious design defects and so take the precautions about the defects earlier. But there must be some features of the labs used in this prototype tests stated as in TS-ISO 9001 [117]. The features of the labs must be as follows:
a) Companies must determine the measurements to be made and the accuracy requires and selects the appropriate inspection, measuring and test equipment that is capable of the necessary accuracy and precision.

b) Companies must identify all inspection, measuring and test equipment that can affect quality and calibrate and adjust them at prescribed intervals.
c) Define the process for calibration of measuring, inspection and test equipment including details of checks, checks methods and acceptance criteria.
d) Identify the test equipment with a suitable indicator to show the calibration status.
e) Maintain calibration records for inspection, measuring and test equipment.
f) Assess and validity of previous inspection, measuring and test results and document them.
g) Ensure that environmental conditions are suitable for testing.
h) Ensure that the handling, preservation and storage of inspection, measuring and test equipment are maintained.
i) Safeguard the test tools from adjustments which would invalidate the calibration setting.

Prototype testing must be done for both military and civilian customers just in the environment they will be used by them. Data are gathered by mathematical models for these testing studies. These data are used both in finishing the marketing plan and feed-back activities for design and development activities.

In this testing activities beta testing and batch testing must be done by the companies. Beta testing is a method to test the product for all functions in breadth of field situations to find the system faults that are more likely to show in the company's more controlled in-house tests before selling to general markets. Also batch testing aims to evaluate whether product complies with the specifications that are determined by the military and the commercial customers [96].

2. Evaluation of the new product performance according to test results

The results from testing and validation phase set up a suitable opportunity for first performance evaluation of the new product. New product performance includes the evaluation of the new product financial, technical and market evaluations. For financial objectives it is looked for the profit, pricing, cost of the products by the tests. For market share objectives, it is evaluated whether or not new product is agreed by the markets. For technical objectives, it is evaluated the required needs of both military and commercial customers' specifications as technologically [82].

K. Full production and launch of the new product

After testing and validation stage the full production of the dual-use new product is done in the company. To produce the product in the number of requested by the customers and to deliver it in time are very important activities for this stage.

So the launch activity must be executed as a strategy in the companies. The product launch requires the largest commitment in time, money and managerial resources [56]. Launch strategy describes the marketing decisions that are necessary to position a new product to its target market [56]. Some consider the launch within the context of NPD, while other studies focus on a strategic entry to a new market. Di-Benedetto [39] states the product launch as a key driver of top performance and the single costliest step in NPD.

1. The necessary activities for effective launch strategy

There are launch skills, strategic launch activities and tactical launch activities for managing effective launch strategy for the companies. These activities can be stated as follows [39] [56]:

a) Launch skills for companies

We can list launch skills for companies as:

(1) Marketing research skills and resources of the companies' are adequate or not for launch.
(2) Sales force skills and resources of the companies' are adequate or not for launch.
(3) Distribution skills and resources of the companies' are adequate or not for launch.
(4) Advertisement and promotion skills and resources of the companies' are adequate or not for launch.
(5) R&D skills and resources of the companies' are adequate or not for launch.
(6) Engineering skills and resources of the companies' are adequate or not for launch.
(7) Manufacturing skills and resources of the companies' are adequate or not for launch.

b) Strategic launch activities for companies in the launch of new product

Strategic launch activities can be listed as:

(1) Interdepartmental committees set up to allow departments to engage in joint decision-making.
(2) Task forces set up to facilitate this interdepartmental collaboration.
(3) Liaison personnel existed to coordinate these efforts.
(4) Cross-functional teams made decisions concerning manufacturing, distribution or logistics and sales strategies.
(5) Logistics operations are integrated with marketing, manufacturing and production operations.
(6) Logistics is involved in planning marketing programs.
(7) Logistics is involved in formulating distribution strategies.
(8) Logistics is involved in coordinating with sales management.
(9) Logistics is involved in service planning after sale.
(10) Logistics is involved in setting replacement policies.

Tactical launch activities for the companies in the launch of new product

a. Quality of selling effort
b. Quality of advertisement.
c. Quality of trade shows, discounts and events of the company;

d. In the service planning, using of trained, qualified and right people.
e. Sufficient inventory available for product.
f. Appropriateness of product pricing;
g. Finalizing plans for manufacturing and marketing;
h. Launching the product to markets;
i. Training of the sales forces.
j. Adequate number of insertions of the product into markets.
k. Managing the distribution of the product properly.
l. To deliver the product on the target time for the customers.
m. To chose the right time for launching the product to commercial markets.

After managing these activities the launch of the dual-use product to both military and commercial markets are finished. After those activities there must be executed some activities in the markets when the products are used by the customers. These activities are can be seen as activities under the product data management.

2. Product data management in the launch activities

The development of computer-based applications for design, engineering and manufacturing has led to an explosion in the volume of product data. The companies have to cope with increasing customer expectation and market requirements. So product data management is urgent for them to execute [98]. Product data management is extracted highly for supporting different specific situations in the new product development process [20].

There are some organizational benefits of product data management as reducing product life-cycle costs, environmental impact, time to market, improving product quality and flexibility of processes.

Product data management also shares data across product development process and along product life cycle. It also secures managed access of data over product life cycle. It provides concurrent process support and simultaneous data sharing. All of these benefits are direct technical benefits of the product data management [98].

In the launch and market management stage there will be activities which must be supported by product data management. These can be listed as follows [39];

a) Interpreting the findings of the market testing.
b) Studying feedback from customers regarding product data during the launch.
c) Studying feedback from customers regarding product data after launch.

Erman [43] states five-stage product management process as strategic planning, concept generation, screening, technical development and commercialization.

L. Marketing of the New Products

The strategic decision for the managers is to determine when the new product is introduced to new markets and what the target performance level should be for the new product [22].

A tool called as real time survey will help to solve this problem for the managers. This survey is primarily used to evaluate the viability of new product ideas in the customer market place. It will be more efficient if it is used at early in the product development stage. By combining certain features of the traditional focus group with features of the sample survey, it is possible to conduct a real time, quantifiable dialog with a representative sample of respondents in the market [61].

An initial lack of information from the market causes unnecessary delays for the new product. But to listen too closely to current markets can also constitute a barrier to commercializing the technology. So the balance must be established within two points [10].

There are some rules for marketing of the products in the market place as follows [40]:

1. Try to make and plan activities which will reduce the waste and lower the cost base of the marketing operations.
2. Plan the sales and marketing strategies carefully in the company.
3. Try to find new business through contracts with key wholesale and retail companies.

1. Marketing decision support system (MDSS)

Marketing decision makers are confronted with an increasing amount of information about markets. Marketing decision support system (MDSS) will be an effective tool for these decision makers. Dealing with the strategic decision tasks has traditionally been the goal of the marketing decision support systems [102]. MDSS contains some marketing models in it and make it possible to do “what-if” analysis for the product [13].

Bruggen et al. [13] state the benefits of MDSS in their study as follows:

a) MDSS is able to improve the performance of marketing decision makers. Because they can prepare the set of the decision variables with this system easily in the direction of the performance.
b) MDSS provides feedback for the whole marketing activities and the relationships between variables in the market. This insight helps decision makers to produce better decisions about marketing activities of the new product.
c) MDSS answers the question about the forces and variables which drive the market.
d) MDSS makes decision maker less susceptible to using adjustment for marketing activities.

2. Marketing-mix Optimization

There are technical models which are used for marketing-mix optimization of the companies. These models can be stated and explained as follows [86] [96]:

a) **Mini-market:** To produce the new product in limited numbers and launch it to the mini-markets firstly to see the market-mix activities results.
b) **Limited Roll-out:** An approach for introducing a new product to the market. The new product is first introduced on a small scale, with the objective to expand slowly in order to limit the market risk. During the introduction the content of the market strategy can be modified.
c) **Test-marketing:** Launching of the products into one or more limited geographic regions in the controlled manner. It is measured the customer responds to the product in these areas. When multiple geographies are used in test, different advertising and pricing activities can be tested and the results are compared in the companies.
d) **Scanner Market:** Special test markets that provide supermarket scanner data from panels of customers to help assess the product's performance.

III. EXPANDED MODEL FOR DUAL-USE NEW PRODUCT DEVELOPMENT

After detailed literature review about both dual-use and new product development, an expanded model for dual-use new product development is established. This model is established according to project management tool developed by Andersen et al. [2], an effective project management tool for the organizations to understand the benefits of the model for People-System-Organization perspectives. To these factors knowledge is added as fourth element. Because after managing of PSO projects, there will be information for the whole. So the model will be in a Knowledge-People-System-Organization (KPSO) format. This format is stated by Basoglu and Oner [9] with a circle (Figure 2).

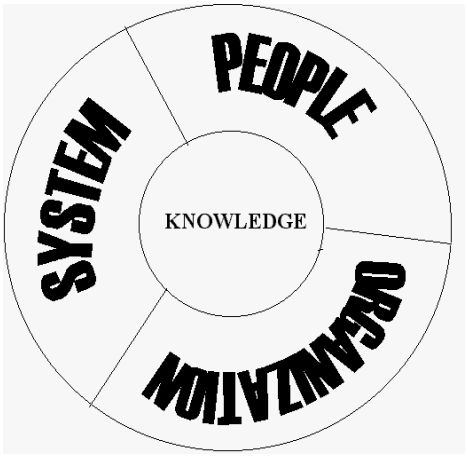

Figure 2: People-system- organization-knowledge circle

Dual-use new product development is also considered as a big project work for the companies. To develop KPSO format and to develop this way of thinking in the companies will make this difficult process easier at all. Because this model will develop the people in the companies as **People** objective, the dual-use product as **System** objective, the companies as **Organization** objective. **Knowledge** is considered in the center of these three objectives and will surround them as a whole.

The dual-use new product development in the study is established as five phases from idea generation to launch and market management. Every phase concludes milestones and every milestone has some activities. Milestone means "checkpoints" which provide an opportunity to understand whether the needs of every stage are managed completely or not [2].

The ideal for the companies in the model is to manage all the activities under the milestones completely and follow the phases in an order. A formal process for guiding the product innovation is useful solution to apply the new product development programs. Stage-gate process presents such a systematic approach in the models.

Salamon and Anheier, [99] states three basic criteria for the quality of a model:

1. It must be economical,
2. It must have significance,
3. It must be explanatory.

These rules are tried to be executed in this model. It is tried to identify true aspects of all phases in process to be economical, it is focused attention on aspects that are not already obvious for its significance and it is tried to be explanatory in every phase of the model.

The model is established by integrating Stage-gate Process System and Organization System. The activities under milestones and whole feed-back system are stated according to this integration. But Go/Kill/Hold/Recycle rules [27, 28] of the Stage-gate process are not applied to the model. Because firstly, the model is aimed to make clear the status of the companies according to phases and activities under these phases.

The audit system developed by Chiesa et al. [19] is applied to the model. Process audit and performance audit are tried to be assessed with the questions.

To make easier for seeing the activities and making relations with the result paths of the study, activity plan will be used as a tool. In the activity plan of every milestone in a phase, there will be activities and the result paths.

In this study, results paths are *market*, *product*, *finance* and *production*. These result paths are points that the company's will aim to achieve a specific type of result. Especially at the new product development processes these four result paths are the key elements. The activities will show result paths in the activity plan and every activity that goes to one or more result paths will create responsibilities for the departments in new product development process.

With this model, the importance of the multi-functional team activities and concurrent engineering activities in a new product development is tried to be stated. Because CE encourages many diverse inputs to the development process at the early stages and provides the design of new products tend to become everyone's business [94]. But the key features for concurrency in a new product development process must be known and applied carefully [78]:

New product principles stated by Souder [107] are also a guide for a success at new product development management and at expanded dual-use new product development stated in that article; those principles are applied to every phase completely. Expanded dual-use new product development model can be seen in Figure 3.

The questionnaire [37] is prepared to measure the capabilities of the companies for the model. The questionnaire has 5 main sections about phases and a general information section:

General Information Section;
Chapter 1: Idea Generation and Preliminary Assessment;
Chapter 2: Concept Writing;
Chapter 3: Product Development;
Chapter 4: Testing and Validation;
Chapter 5: Full Production, Launch, Market and Data Management.

General information section gets critical information about companies and is not included in scoring of the companies. Other sections are the phases of the expanded model and they are explained in detail as milestones and their activities. These activities under each milestone of main sections are transformed into questions which construct the questionnaire. The firms are intended to be audited and scored with respect to the activities of the expanded model. The questionnaire contains questions which will clarify the sufficiency of the companies in executing the activities stated in the expanded model.

The scoring system measures the activities via Likert scale with 6 scales starting from 0 (which means 0 % of operational capability) through 5 (which means 100 % of operational capability). The Likert scale selected by the company in each question indicates the score of the company for that question. The summation of each score establishes score of relevant phase obtained by the company. Total scores of the companies in a phase need to be transformed into capability index as percentage since each phase has equal importance weight on whole process but different total scores because of different numbers of questions.

The purpose of general information section is to get information from the companies about:

- the responsibility level for development process in the company; : [30] [55] [59] [75] [88] [94] [106] [119].
- efficiency level of the company in application of a development model (if there is one); [6].
- the level of the quality studies in the company; [115] [23] [42] [126].
- practices in R&D area. : [16] [31] [48] [51] [80] [88].

The evaluation of the companies according to model begins with first chapter of the questionnaire named as Idea Generation and Preliminary Assessment. This chapter has 68 questions about the main activities listed below;

- dual-use technology methods, transfer policies, and dual-use policies;
- dual-use new product complexity factors;
- supplier management system;
- problems about integration of dual-use and new product development process;
- organization type and its flexibility in the company;
- engineering abilities for dual-use new product development;
- human resources policies and management;
- evaluation of the abilities for company about dual-use new product development;
- idea generation methods;
- making idea strategy;
- executing techniques of preliminary assessment about dual-use new product in the company;
- market conditions which will affect the exact definition of dual-use new product;
- level of the activities with military customers about military standards of the dual-use new product;
- using level of the resource allocation methods in the company.

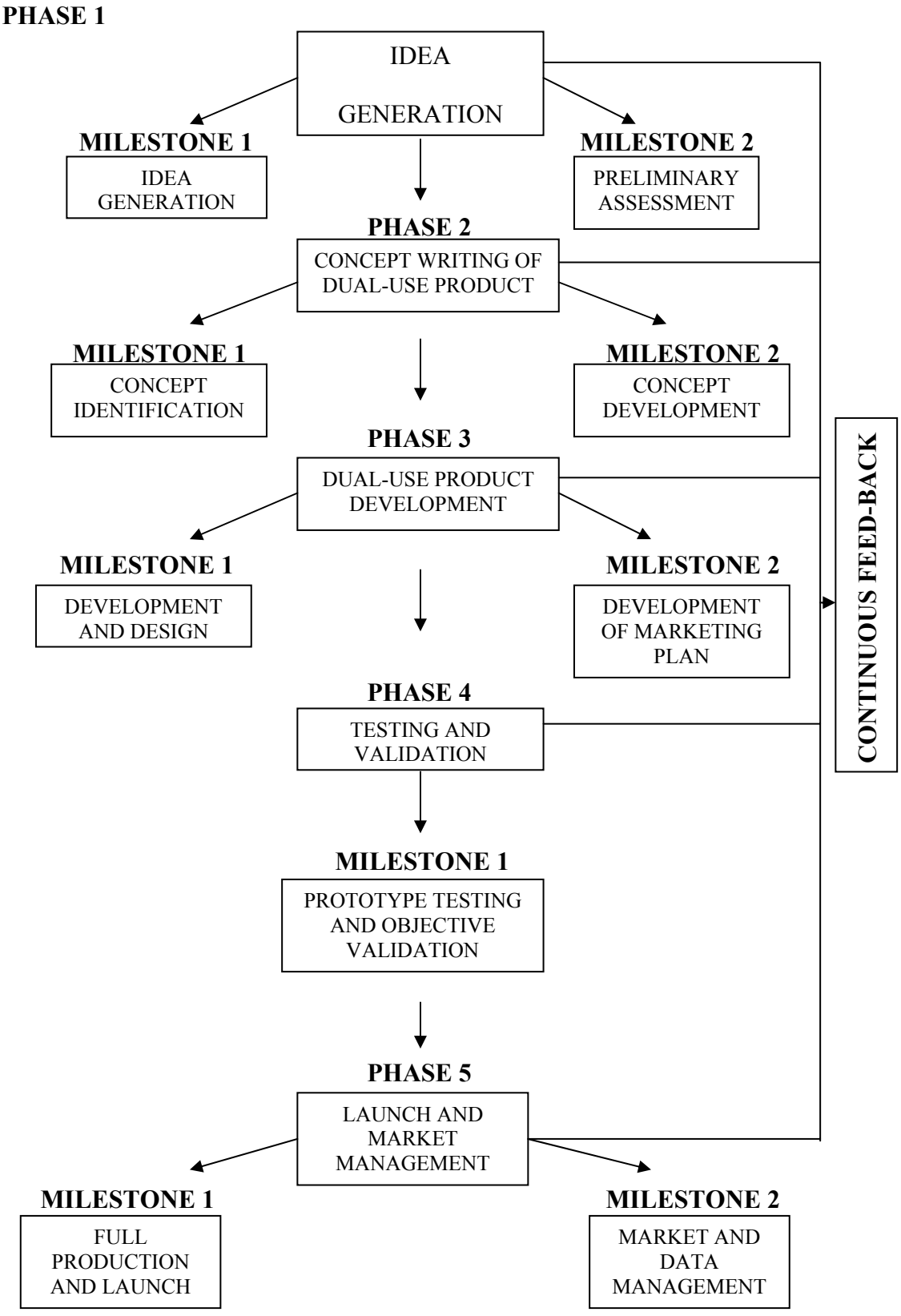

Figure 3 Expanded dual-use new product development model

Concept Writing chapter of the questionnaire has 28 questions . The main activities which are tried to be evaluated for concept writing phase are as follows:

- The level of feasibility studies in the companies;
- The level of expertise in concept writing;
- The ability of the company about finding niche markets for dual-use new product;
- The application levels of strategic and operational flexibility rules of product variety management in the companies;
- The ability of concept engineering techniques in the companies;
- The application levels of "Quality Function Deployment" and "Concept Test" methods in concept development activities of the companies.

Following chapter is "Development of the Dual-Use New Product". There are 42 questions evaluating the activities related to the development and design of a dual-use new product. These activities can be listed in general as follows:

The evaluation of development and design activities;

- The ability of the companies to measure the required engineering capabilities in executing activities.
- Using new product prototypes,
- The application level of the conjoint analysis technique;
- The newness level of machine and equipment;
- The level of design activities;
- The application level of engineering abilities related with design process;
- Evaluating the problem definition rules in the companies for marketing plan;
- The level of activities of developing marketing plans.

Fourth phase is Testing and Validation of Dual-Use New Product including 19 questions which measure the followings:

- The level of testing dual-use new product prototype in the companies with participation of military and commercial customers;
- The level of application in testing techniques like alpha, beta and batch tests;
- The conditions of the laboratories for testing and validating the dual-use new product.
- The validation level of dual-use new product technical, financial and market-share objectives following test results.

Fifth and the last phase of the model and questionnaire is about the activities for full production, launch and market management of dual-use new product. There are 35 questions evaluating related activities and they are listed mainly as follows:

- Usage level of a strategy for full production and launch of the new products.
- The level of launch skills.
- The level of application in strategic and tactical launch activities.
- The level of applications in product data management activities.
- The level of application in "Real-time Survey" technique.
- Evaluation of activities in optimization of market sources.

There are total 192 questions in questionnaire which evaluate the activities in expanded dual-use new product development model.

Questionnaire is subjected to reliability analysis and factor analysis by using SPSS package program. Firstly, reliability analysis is applied to the phases as a whole. Reliability analysis of phase 2 as an example is shown below at Table 1.

Secondly, reliability analysis is followed by factor analysis to the phases. Factor Eigen values are found with that procedure and SPSS identified different factors for each phase in the analysis: (see Table 2).

Finally, the factors revealed by factor analysis are subjected to reliability analysis separately and reliable questions in the questionnaire are found with that procedure. (see Table 3)

TABLE 1: RELIABILITY ANALYSIS OF PHASE 2 QUESTIONS

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
Q2.1.1	84,6364	336,4545	,7169	,8626
Q2.1.2	84,7273	360,2182	-,1100	,8763
Q2.1.3	85,6364	346,8545	,2810	,8685
Q2.1.4	85,6364	328,0545	,4982	,8631
Q2.2.1	86,0909	323,0909	,4908	,8632
Q2.2.2	86,2727	312,4182	,6204	,8587
Q2.3.1	84,8182	352,1636	,0959	,8717
Q2.3.2	85,0000	344,6000	,2491	,8692
Q2.3.3	85,8182	333,5636	,3193	,8686
Q2.3.4	86,0909	342,4909	,2495	,8695
Q2.3.5	87,8182	357,1636	-,0355	,8735
Q2.3.6	84,9091	341,4909	,5708	,8650
Q2.3.7	86,1818	340,9636	,2185	,8713
Q2.3.8	85,9091	343,2909	,2124	,8707
Q2.3.9	84,4545	319,0727	,6606	,8585
Q2.4	85,9091	351,0909	,0241	,8798
Q2.5.1	85,1818	314,5636	,7896	,8553
Q2.5.2	85,5455	326,4727	,6709	,8599
Q2.5.3	85,1818	330,7636	,4874	,8636
Q2.5.4	85,4545	313,6727	,7323	,8561
Q2.5.5	85,8182	306,3636	,8851	,8515
Q2.6.1	85,4545	318,8727	,7409	,8571
Q2.6.2	86,0909	317,6909	,5410	,8615
Q2.6.3	85,8182	330,3636	,4060	,8657
Q2.6.4	85,3636	331,6545	,4159	,8654
Q2.7	86,0909	325,2909	,4944	,8631
Q2.7.1	86,2727	351,2182	,0644	,8744
Q2.7.2	85,9091	333,4909	,4257	,8652

Reliability Coefficients

N of Cases = 11,0 N of Items = 28

Alpha = ,8698

TABLE 2 FACTOR EIGENVALUES FOR PHASE 2

Variable	Communality	Factor	Eigen value	Pct of Var	Cum Pct
Q2.1.1	1,00000	1	9,17839	32,8	32,8
SQ21.2	1,00000	2	4,43134	15,8	48,6
Q2.1.3	1,00000	3	4,03222	14,4	63,0
Q2.1.4	1,00000	4	3,37429	12,1	75,1
Q2.2.1	1,00000	5	1,99612	7,1	82,2
Q2.2.2	1,00000	6	1,69596	6,1	88,2
Q2.3.1	1,00000	7	1,16278	4,2	92,4

TABLE 3: RELIABILITY ANALYSIS OF FACTOR 1 IN PHASE 2

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
Q2.1.1	31,0909	124,8909	,6295	,9524
Q2.3.9	30,9091	104,8909	,9388	,9376
Q2.5.1	31,6364	105,8545	,9530	,9372
Q2.5.2	32,0000	112,6000	,8705	,9421
Q2.5.3	31,6364	109,4545	,8671	,9413
Q2.5.4	31,9091	106,6909	,8303	,9429
Q2.6.1	31,9091	111,4909	,7884	,9447
Q2.6.4	31,8182	110,5636	,7312	,9474
Q2.5.5	32,2727	109,2182	,7535	,9465
Q2.6.3	32,2727	112,2182	,6206	,9533

Reliability Coefficients

N of Cases = 11,0 N of Items = 10

Alpha = ,9500

IV. FIELD STUDY

Expanded dual-use new product model is applied on 11 defense industry firms with a detailed questionnaire. Performance and process audits which are stated by Chiesa et al. [19] were used. Five of these firms are from electronics industry, two of them are from automotive industry, three of them from machine and its components manufacturing industry, one of them is from ammunition industry in Turkey. Descriptions of companies are shown in Table 4.

The surveyed companies were requested to indicate their defense proportion in total turnover, export sales and R&D expenditures. Out of 11 companies, two rejected to give this information for their confidentiality. The surveyed 9 companies construct 26% in the total amount of defense companies with respect to their defense proportion to total turnover. The same companies construct 24 % with respect to their proportion of defense export sales to total export sales and 45 % with respect to their proportion of R&D expenditures to total R&D expenditures. These proportions indicate the strength of sample companies in the total population.

As seen on the Table 5, all the companies participated in the research (which gave their personnel information) are big-size companies (having more than 500 employees). The average proportion of total engineers to total employees is 24,6 %. It is suggested that the increase in the proportion will have a positive effect on the operational capabilities of the companies in Dual-use new product development process.

TABLE 4: DESCRIPTIONS OF COMPANIES

	Turnover $			**Export** **$**			**R&D** **$**		
Company	Total	Defense Industry Proportion		Total	Defense. Industry Proportion		Total	Defense Industry Proportion	
1	-	-	-	-	-	-	-	-	-
2	117,223,000	79	92,606,170	3,607,000	100	3,607,000	1,288,000	74	953,120
3	223,781,000	9	20,140,290	54,867,000	0	0	16,000,000	32	5,120,000
4	50,000,000	1	500,000	7,837,000	0	0	100,000	8	8,000
5	173,000,000	0	0	34,000,000	0	0	9,668,000	0	0
6	129,974,880	12	15,596,986	16,000	7	1,120	3,604,000	7	252,280
7	194,000,000	74	143,560,000	23,300,000	66	15,378,000	15,520,000	74	11,484,800
8	35,000,000	27	9,450,000	1,350,000	78	1,053,000	1,000,000	82	820,000
9	18,000,923	2	360,018	10,000,000	0	0	0	0	0
10	-	-	-	-	-	-	-	-	-
11	50,000,000	100	50,000,000	13,587,000	100	13,587,000	2,621,000	100	2,621,000
Others			**792,760,743**			**64,369,431**			**22,994,318**
Applied			**281,853,446**			**20,039,120**			**18,638,200**
Total			**1,074,614,189**			**84,408,551**			**41,632,518**
%			**0.262**			**0.237**			**0.448**

TABLE5: PERSONNEL PROFILE OF SURVEYED COMPANIES

Company No.	**Total Employee Number**	**Total Engineer Number**	**Total Engineer / Total Employee**
Company 1	-	-	-
Company 2	575	115	20%
Company 3	1062	435	41%
Company 4	535	81	15%
Company 5	800	298	37%
Company 6	820	194	24%
Company 7	2972	880	30%
Company 8	517	68	13%
Company 9	600	27	4,5%
Company 10	-	-	-
Company 11	660	243	36,8%
Mean	949	260	24,6%

The scores of the companies are calculated according to their answers for each phase of the model. The scores of each phase is shown in Table 6. The names of the companies are not revealed for confidentiality principle.

TABLE 6: SCORES OF THE COMPANIES FOR THE MODEL

Company	Chpt.1 Score (Total 340)	Chpt.2 Score (Total 140)	Chpt.3 Score (Total 210)	Chpt.4 Score (Total 95)	Chpt.5 Score (Total 175)
1	**253**	**123**	144	76	**135**
2	245	109	**170**	83	125
3	234	96	154	**91**	104
4	233	96	153	84	117
5	213	88	162	83	114
6	191	89	143	69	124
7	208	79	129	83	81
8	174	71	113	***63***	105
9	179	83	***112***	68	***77***
10	137	***51***	132	75	102
11	***124***	92	124	70	79
Average	199.2	88.8	139.6	76.8	105.7

This table is prepared according to companies' answers to the questions in the phases. Bold scores in each phase shows the best and the worst scored companies in the table. But this table does not mean anything for evaluation. Because in the model; important thing is to find the success percentages of the phases for the companies. The percentage success scores of the companies are shown in Table 7:

TABLE 7: SUCCESS PERCENTAGES OF THE COMPANIES FOR THE MODEL

Company	Success Percentage For Chapter 1	Success Percentage For Chapter 2	Success Percentage For Chapter 3	Success Percentage For Chapter 4	Success Percentage For Chapter 5
1	**74.4**	**87.9**	68.6	80.0	**77.1**
2	72.1	77.9	**81.0**	87.4	71.4
3	68.8	68.6	73.3	**95.8**	59.4
4	68.5	68.6	72.9	88.4	66.9
5	62.7	62.9	77.1	87.4	65.1
6	56.2	63.6	68.1	72.6	70.9
7	61.2	56.4	61.4	87.4	46.3
8	51.2	50.7	53.8	**66.3**	60.0
9	52.7	59.3	**53.3**	71.6	44.0
10	40.3	**36.4**	62.9	79.0	58.3
11	**36.5**	65.7	59.0	73.7	**45.1**

V. DISCUSSION AND CONCLUSION

In this article, a process model framework integrating dual-use technology with new product development process were tried to be constructed. Dual-use technology which is efficiently used especially in USA and some European countries, enables usage of the product in both military and commercial markets. Military can get the benefits of cost reduction in products which do not require special design and endanger security by utilization of dual-use technology. Dual-use technology can also provide commercial companies the opportunity to enlarge their market share by marketing their products to both military and commercial sectors. In addition to the benefits for military and commercial companies, this technology has a major effect on reduction of defense budget and on development of national economy.

In addition to complexity of both new product development process and dual-use technology, the integration of these two requires more challenging work. Companies need to gain big reservoir of knowledge in the areas of dual-use technology and new product development process activities in order to integrate these two efficiently.

Expanded dual-use new product development model which aimed to integrate dual-use with new product development was developed in order to facilitate the application of the model, Goal Directed Project Management method. If the dual-use related parts of the model are extracted, the rest of the model can be used as a separate model for development of new products. In the model there

are five phases starting from idea generation and preliminary assessment through launch which include different activities. Sufficiency in execution of these activities determines the quality of produced dual-use new product.

A questionnaire as a survey instrument was applied to the sample companies in order to draw a capability profile in related activities of five phases. For that purpose, the questionnaire including all related activities was prepared. The model intends to draw capability profile by scoring the each phase for the companies. Scoring of the each phase would lead to identification of deficiencies in related phases. The awareness of these deficiencies would provide companies opportunity to improve their new product development processes.

This study reveals that in the sample companies, in idea generation and preliminary assessment phase; the best scored company has 74, 4% success percentage, the worst scored company has 36, 5 % success percentage and average of all companies for Phase 1 is 58,6 % success percentage. If the answers are examined according to the phase these general deficiencies can be defined for the companies in Phase 1:

The activities related to dual-use methods, policies and technology transfer techniques are used improperly. The average success percentage of all surveyed companies is 55%. Insufficiencies in related activities are attributed to the lack of knowledge which constructs a major barrier to successful management of dual-use technology. Technical department about dual-use technology in companies may provide a considerable effect on this type of new product development processes in the companies. This department may work in interrelation with military customers to have full knowledge about the specifications of military sector. This knowledge will define the availability about dual-use application conditions of new development products.

Results of questionnaire reveal both qualitative and quantitative techniques which have great impact on all related phases of dual-use new product, were not used sufficiently in the surveyed companies (which indicate a major weakness in the sector). These are idea generation and resource allocation techniques in Phase 1, concept testing in Phase 2, R&D index, Staffing ratios, conjoint analysis, engineering ability techniques in Phase 3, test techniques in Phase 4 and market optimization techniques in Phase 5. There are 37 questions about these techniques in questionnaire and application capability average of the companies for these techniques according to answers is 48 %. Collaboration of companies with universities about developing of these techniques can be an answer for this problem. Collaboration can be provided as follows for companies:

- Sponsoring of companies to the university research laboratories;
- Alliance in R&D projects of both university and companies;
- Dissemination of company technical personnel to universities for graduate studies which have an impact on the knowledge base of the companies.

Functional organization structures in most of the companies inhibit the effective usage of multi-functional teams and concurrent engineering activities which are vital for successful new product development. 4 of 11 surveyed companies still use functional organization type in their companies and it is suggested to enhance the usage of multi-functional teams and concurrent engineering activities in new product development process by using matrix organization structures.

Companies average related with human resources and policies management in questionnaire is 60%. Companies are not in much effort about establishing company culture throughout their organizations. Especially in new product development activities; company culture must be established in order to prevent resistance to technological change within the members of companies. This culture must not be affected by the differences in the multi-functional departments. Company culture can be established with some activities in companies:

- By applying effective training facilities throughout the company to form organizational learning;
- By giving necessary importance to human resources and policies management;
- By establishing an effective reward system in whole organization for motivation of personnel in all levels.

In concept writing phase; average success percentage is 63, 4%, the best scored company's percentage is 87, 9 and the worst scored company's percentage is 36, 4. It is revealed that the importance of common terminology on identification of technical specifications is not understood by companies in Phase 2. Application levels of companies about concept writing and average is 51%. That causes unnecessary cost and time losses especially in design and development phases of dual-use new product. Both military and commercial customers define their own needs in their own terminology. To understand these needs can only be understood by a professional unit. R&D department may form a special expert unit which has capability about for providing common terminology with both military and commercial customers. This unit also will provide to form concept definition of dual-use new product in the development process.

Companies have some deficiencies about niche market strategies and product variety management in Phase 2. 18 questions are asked to surveyed companies about these activities and average success percentage of the companies about these issues is 65%. These two issues will define the product successes for companies and must be developed. R&D departments may give more importance for these activities in this Phase.

Companies have 66, 5 % average success in development and design activities. The best scored company has 81, 0 % success and the worst scored has 53, 3 % success in Phase 3. Especially marketing plan development activities are not applied properly in this phase.

Marketing plan must be developed in this phase efficiently without waiting for marketing product phase. R&D department may execute activities for these facilities by coordinating multi-functional departments about this issue.

Using level of fast prototype techniques in companies is 33 %. Fast prototyping techniques are not effectively used in most surveyed companies. The advantages of fast prototyping of product about cost and time must be understood in the companies. Companies can use technology officers for following these developments in their companies. These technology officers will also provide to overcome the structural barriers interrelated with technological developments in the companies.

Companies are successful in testing and validation phase of the model with an average 80, 9 %. The worst scored company has 66, 3 % and the best scored company has 95,8 % success for this phase. Application of the test techniques can be developed by the companies for full success in this phase.

Full production, launch and market management phase has 60, 4 % average for all companies. The best scored company has 77, 1 % and the worst scored company has 77,1 % success in the last phase of the model.

Using different department for production data management and application of real-survey technique for getting real data for products in companies is 55 %. Market management can be executed with effective product data management in the companies. Product data management is not usually applied professionally in surveyed companies. If effective data management is applied then data will be stored "ready to use" by multi-functional teams in the company. Marketing department can form a different unit for product data management which has expert personnel for this work. Real-time survey about dual-use new product may be also be applied by this department for real-time data of new product.

These results present a general structure of companies about expanded dual-use new product development model activities. Examination of these general results and each company's results may give some ideas to companies about assessing their capabilities in dual-use new product development.

The image of dual-use product can be seen simple at first glance. But this simplicity is misleading. Because new product development process is difficult for the companies at all and with addition of dual-use feature to this process, the difficulty will be increased more. But the answer to solve this difficulty lies in the systematic approach to dual-use new product development. If the activities are defined clearly in a new product development model and the definition of the idea is made clearly then to manage this development will be much easier for the companies. That article tries to explain such a model and an questionnaire which is developed according to that model to create an opportunity for the companies about testing their capabilities for dual-use new product development and gives some significant results on 11 companies chosen from Turkey.

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