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Technology Roadmapping in Defense Industry

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Abstract**—**The rapid progress of technology in today's competitive conditions has also accelerated companies' technology development activities. As a result, companies are paying more attention to R&D studies and are beginning to allocate a larger share to R&D projects. A more systematic, comprehensive, target-oriented implementation of R&D studies is crucial for the company to achieve successful results. As a consequence, Technology Roadmap (TRM) is gaining importance as a management tool. It has critical prospects for achieving medium and long term success as it contains decisions about past business, future plans, technological infrastructure. When studies on TRM are examined, projects to be placed on the roadmap are selected by many different methods. Generally preferred methods are based on multi-criteria decision making methods. Management of selected projects becomes an important point after the selection phase of the projects. At this stage, TRM are used. TRM can be created in many different ways so that each institution can prepare its own Technology Roadmap according to their strategic plan. Depending on the intended use, there can be TRM with different layers at different sizes. In the evaluation phase of the R&D projects and in the creation of the TRM, HAVELSAN, Turkey's largest defense company in the software field, carries out this process with great care and diligence. At the beginning, suggested R&D projects are evaluated by the Technology Management Board (TMB) of HAVELSAN in accordance with the company's resources, objectives, and targets. These projects are presented to the TMB periodically for evaluation within the framework of certain criteria by board members. After the necessary steps have been passed, the approved projects are added to the time-based TRM, which is composed of four layers as market, product, project and technology. The use of a four-layered roadmap provides a clearer understanding and visualization of company strategy and objectives. This study demonstrates the benefits of using TRM, four-layered Technology Roadmapping and the possibilities for the institutions in the defense industry.

Keywords**—**Project selection, R&D in defense industry, R&D project selection, technology roadmapping

I. Introduction

IN the global competitive environment where technology has developed rapidly, the technology development activities of the companies have accelerated and the importance given to the R&D projects which are the main trigger of the inter-country economic development has increased [1]. With the R&D projects, which have become the main element of the competition, companies aim to increase technological and scientific knowledge and to direct the technology Since the available resources are limited, it is important to use them effectively. Failure to select appropriate projects will result in loss of utility and unnecessary resource spending. As a result, companies should attach importance to the project selection and monitoring at the same time.

TRM are the basic planning tool according to the purpose of use for the activities to be carried out by the technology strategy, that is determined and planned according to the strategic plans and business plans, business units, which include the target technologies, project plans, capabilities to be acquired, organizational culture, product and market targets [2]. It is used with a time-based map prepared to see the long-term goals of the company, to work in harmony with the strategic plan, to develop a common understanding in the company, to make more effective investment decisions. TRM used for many different purposes were also needed to track R&D projects, which are becoming more difficult due to increased numbers. They can be used to track selected projects on a time-based map, according to the format of the TRM. Projects can be linked to different layers and the company's overall picture can be viewed.

Technology Roadmapping covers all stages from the selection of projects to be placed on the map to the connections to be established with the layers. Strategic planning and company resources are the focus areas for all these steps. Three questions are answered with the generated TRM; Where are we going?, Where are we now? and How can we get there? A well-established TRM has critical importance to grow, develop, and manage future activities by protecting the company's competitive position [3].

TRM are more important and critical for the Defense Industry, which has great prominence in the defense of a country. The need for defense products differs according to the products in other sectors. The application of new technologies to defense products and the fact that defense possibilities are kept at the highest level at any time have caused this difference and have increased the importance given to the R&D. Due to the high cost in the defense industry, the projects that will be placed on the TRM should be selected more carefully. The areas needed should be well defined, and unnecessary expenditures should be avoided. This article discusses the process of forming the defense Industry's TRM on the basis of Turkey's largest software defense company HAVELSAN.

II. Literature Review

When studies related to the topic are examined, it has been determined that there are many different methods for preparing TRM. The common point is that all studies are carried out according to the strategic plan and TRM are time-based.

When the selection studies of the R&D projects are examined, it is seen that each method has a complex decision making process because it contains many different criteria which are prepared according to the strategic plan and the company's resources. Firstly, after the criteria for project

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selection are determined, project selection is made according to expert opinions or a methodological study. Expert opinions benefit from expert knowledge and ability to evaluate company resources. Following the selection of criteria in methodological studies, these criteria are weighted and projects are scored with these weights by decision makers. Lately, the fact that decision makers cannot say anything precisely at the beginning of the problem has enabled the development of VIKOR and TOPSIS methods from fuzzy and multi-criteria decision making exercises using linguistic expressions [4], [5].

When Technology Roadmapping studies are examined, it is seen that roadmaps are formed with many different purposes and methods. Projects can be created according to the criteria set in the TRM, or roadmaps can be created after projects are selected. TRM can be developed in many different areas according to the company's future plans/visions/objectives; product planning, service/capability planning, strategic planning, long-range planning, process planning, integration planning, etc. After the topic to be worked on is selected, the related layers are determined and the roadmap is filled. In general, the top tiers are related to know-why, which indicates what the company is aiming for. Bottom layers are related to the know-how of the company's resources. The middle layer shows the know-what part by establishing a link between purpose and resources [3]. In addition, the TRM can have different formats so that users can visualize them in a way that suits for them. It can have multiple layers, bars, tables, graphs, pictorial representations, flow charts, single layer, text, etc. In TRM, like project selection stages, companies are able to make the most appropriate work for them. What is important in all these studies is that the company has to choose the best ones among the samples and has to know the resources, the strategic plan, and the future goals as well. In all these studies, it is important that companies should know their resources, strategic plans, future goals and according to these inputs, they should choose the best fit TRM type. It should not be forgotten that all these studies are aimed at establishing and protecting the update of TRM, which are a vital system and ensure that the company has more control over past, present and future plans [6]. By creating an effective roadmap for the company, project repetitions are avoided and company resources are used in the most efficient way. Fig. 1 represents the general structure of TRM with functional perspectives, roadmap framework, knowledge types, and information types [3].

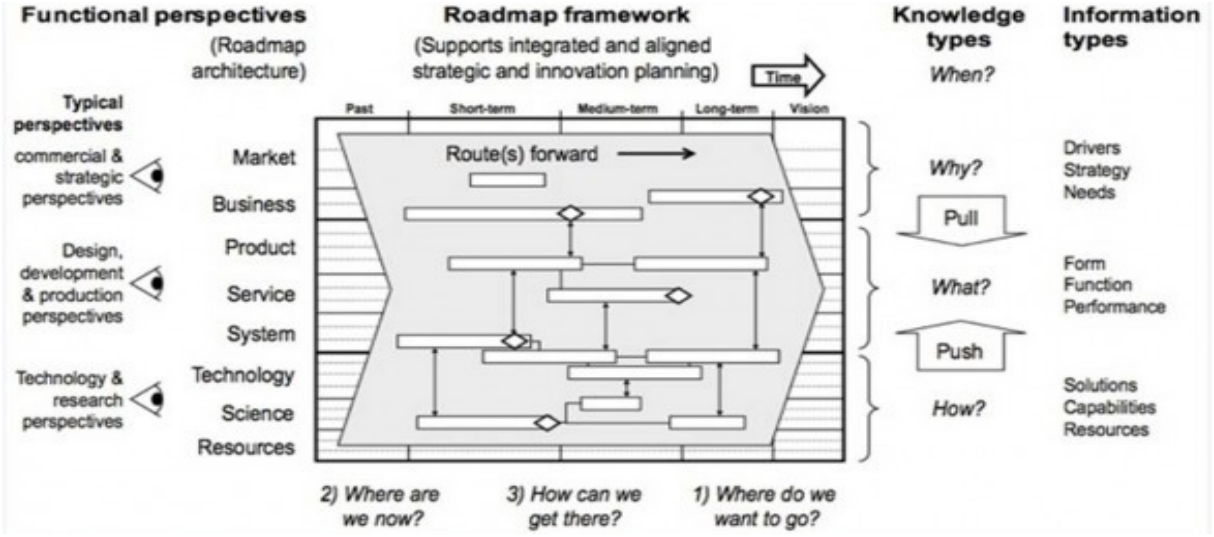

Fig. 1 General form of TRM

This study will examine HAVELSAN's project selection steps like experts' opinions and the process of creating a roadmap consisting of four layers such as technology, project, product and market.

III. Technology Roadmapping in Defense Industry (HAVELSAN)

A. About HAVELSAN

HAVELSAN is the leading defense industry technology company established in 1982. HAVELSAN develops indigenous systems for domestic and foreign military, public and private sector and provides smart solutions based on today's state-of-the-art technologies. Four main fields of HAVELSAN are Command and Control Combat Systems, Training and Simulation Technologies, Country and Cyber Security Solutions, and Management Information Systems.

HAVELSAN aims to develop high-tech products with the potential of commercialization by giving importance to the research, development and innovation potential within the scope of engineering activities by giving importance to R&D studies. For this purpose, the TMB has been established to evaluate the candidates of the R&D projects, and the TRM has been established to follow the selected projects.

B. Technology Management Board

The TMB is a board that evaluates all initiatives implemented by strategic business units at HAVELSAN in

terms of Technology Management and evaluates new or ongoing R&D proposals. It takes place at least once every two weeks with the participation of the director, group manager and manager. The selection of members is a critical issue because one of the duties of the TMB is the evaluation of R&D projects. Participants' technical competencies must be sufficient, they must be aware of the latest technologies by following the trends in the world, and should be in a position to decide on strategic objectives and resources within the company. In selecting the proposed R&D projects, it will be more efficient for members to know both the trends world-wide and the company. HAVELSAN attaches great importance to the development and progress of the company by encouraging employees to participate in technology fairs organized around the world and providing trend analysis to the company with the help of major research and advisory firms such as GARTNER.

The departments that are considering starting an R&D project inform these requests to the TMB coordination team in HAVELSAN. When project candidates are evaluated, the current situation of HAVELSAN as well as information such as the target purpose, similar projects, technology analysis, cost, potential market, etc. of the proposed project is evaluated. The status of the project will be determined according to the common decision between the members of the board. In some exceptional cases (e.g. budget), the subject is transferred to the upper boards when the predetermined limit is exceeded.

C. Placement of the Projects in the TRM

In HAVELSAN, the TRM consist of four layers, i.e. bottom to top technology, project, product and market, these layers are managed by software. As the Robert Phall said, it is much easier to manage TRM with a tool.[3] With the TRM standardized using software, extra features such as versioning possibility, detailed search ability, common usage possibility, large picture can be seen and customized according to need are obtained. The TRM enables to plan the projects of HAVELSAN with timing, employment and budgeting information. In software tool, the TRM is integrated with four different modules: Technology Taxonomy, Project Module, Product Module and Market Taxonomy. It is used to visualize collected information. Roadmaps can be changed on the related modules.

As it can be seen in Fig. 2, the HAVELSAN TRM tool consists of four layers, with many bars on each layer, and a representation of the interrelationships of these bars. With filtering features layers can be displayed in any combination. For example, only project and technology or market and technological layers can be displayed. Other filtering features can be based on the historical and the Technology Readiness Level. Briefly, user can do customization according to need.

When any bar is selected on a layer, the connections to the other layers are shown and only the related parts are visible, as can be seen in Fig. 3. For example, when any project bar is clicked on, the related technology, product, market information are also accessed. Other projects and unrelated technology, products, market information look faded. This will provide a clearer indication of the desired feature. On the right side of the screen, the information panel about the selected bar can be seen. The selection process can be implemented for each bar in the layers.

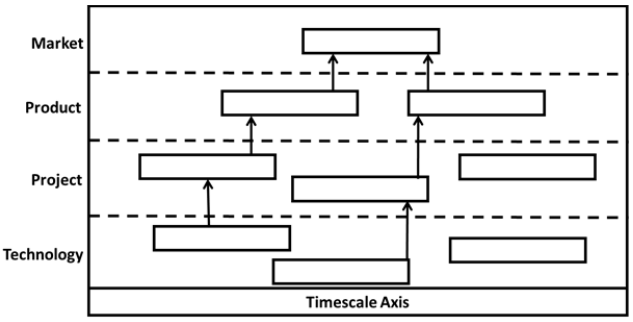

Fig. 2 TRM tool representation

In HAVELSAN, selected projects are placed in the project layer after being evaluated in TMB according to disciplines such as technology and market tendencies, opportunities, product strategies and plans, human resources and financial structure in Strategic Plan and business plans. If a product recommendation is made, the project is converted to the product, so the TRM is filled from bottom to top based on the projects. Project information, initial, targeted and finished project Technology Readiness Levels are determined of each project. Project Technology Readiness Level is a generally accepted measurement system used to assess the maturity level of projects. There are nine projects Technology Readiness Level (TRL); TRL-1 is the lowest, TRL-9 is the highest [7]. Project TRLs are important for the control of technical and technological risks on a project basis and for the progress of the project.

At the technology layer, technologies used to develop projects are available. The technology choice is made by the Technology Taxonomy, which is composed of three compartments classified according to the technological fields that are developed for the defense industry. More than one technology can be selected for each project. Descriptions of selected technologies can be seen without complication with the software, and thus a user viewing the TRM can more easily grasp the connection between the four layers. After the fields of technology are identified, product information is entered. Information such as product description, cost, calendar, etc. for the projects planned to be converted into product are included in the TRM. Finally, the market layer is filled. Possible suitable environments for the commercialization of the developed projects and products are evaluated by the Market Taxonomy which includes the four main fields of activity of HAVELSAN which is similar to the Technology Taxonomy. If it is targeted to enter with the project or product a market area, which is selected from the Market Taxonomy and displayed on the TRM.

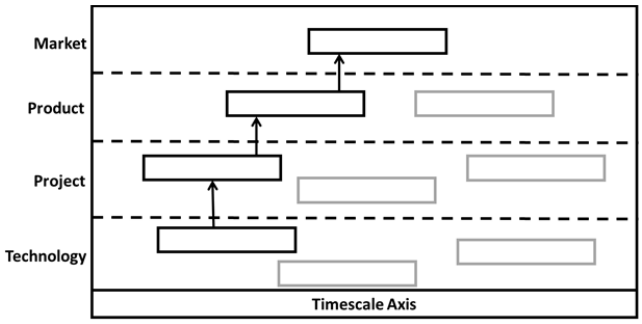

Fig. 3 Visualization after the project is selected

At HAVELSAN, it is possible to see, at first sight, which technology will be developed with which technology, which products will be concentrated on and which market will be entered. In short, when it is thought that the project or the product appeals to more than one market, TRM tool in HAVELSAN is used as a decision support system by managing a complexity that has become almost impossible to manage in a layered manner on a timescale axis. It is possible to see the past projects, past technologies, maturity of projects, future market/product/project/technology information with TRM. In this respect, it is prevented to invest in similar projects by seeing the planned projects/products in the company and provides more benefits by better managing company resources.

The TRM is a live demonstration of the company's status and it makes sense if it is up-to-date. Therefore, care should be taken to maintain the update of the TRM. HAVELSAN is making at least one update of the TRM every year. It is necessary to inform the TMB of the requests of the projects for the update. When update requests are accepted, the changes are reflected in the TRM.

IV. Conclusion

Due to rapid changes in technology and customer expectations, the ever-shorter life span of projects and products has increased the importance given to R&D projects. They provide cost reduction through the development of new projects and products, the improvement of existing ones, and the enhancement of efficiency of company processes. For this reason, it is very important to select the R&D projects that will make the most contribution to the strategic objectives and make profit for the company. The TRM used for the development of planned R&D projects and for monitoring existing projects and products are effective management systems.

HAVELSAN, which made the selection of R&D projects in the TMB, started to see the effects of the use of TRM positively. The ongoing work on the creation of the TRM in HAVELSAN has been adopted by the employees and usage with the TRM tool has been increasing. The greatest benefit is that people working in different parts of the company are able to be aware of the other parts. In this way, research projects for different areas have been started instead of projects targeting the same technologies or the same market. Also, looking at the general situation of the company such as planned/existing projects or products, everything can be viewed in detail in the TRM instead of getting information from each department. Briefly, to be in the top rankings in a rapidly increasing competitive environment, TRM are becoming an important point.

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