Journal of Management, Marketing and Logistics
Year: 2017 Volume: 4 Issue: 3

DEFINING A TECHNOLOGY MANAGEMENT FRAMEWORK WITHIN A DEFENSE ENTERPRISE

DOI: 10.17261/Pressacademia.2017.492
JMML- V.4-ISS.3-2017(12)-p.301-309

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To cite this document
Kaya, P., T. Erol and İ. G. Ozbilgin (2017). Defining a technology management framework within a defense enterprise. Journal of Management, Marketing and Logistics (JMML), V.4, Iss.3, p.301-309.
Permemant link to this document: http://doi.org/10.17261/Pressacademia.2017.492

ABSTRACT

Purpose- In this paper, the methodology of definition a tailored Technology Management (TM) Framework for a large scale enterprise defense company (HAVELSAN) will be explained briefly, and selected subset of TMF components in the company will be further discussed. The method of managing technologies in enterprises depends primarily on the size of the company and its organizational structure.

Methodology- The main purpose of this paper is the identification and analysis of the factors influencing the manner in which technologies are managed in big enterprise companies especially focused on defense industry.

Findings- The concepts that are investigated and the methodologies that are developed in this study are primarily based on the case of technology management framework within a defence technology enterprise.

Conclusion- The methods of defining a newly introduced Technology Management Framework (TMF) will help to enhance knowledge related to the development of methods used for technology management and the technology management tools in relation with each other.

Keywords: Technology management, technology management framework, technology taxonomy, technology roadmap, technology radar, technology readiness level, technology competency.
JEL Codes: O32

1. INTRODUCTION

The term TM has been defined as, combination of the disciplines of engineering and management sciences with the purpose of planning, development and implementation of technological capabilities which will enable the implementation of strategic and operational objectives of the organization [1]. Therefore, TM is a set of management disciplines that allows organizations to manage their technological fundamentals to create competitive advantage, the advantages should be clearly identified from the beginning.

Many managers are aware of the strategic importance of technology in delivering value and competitive advantage to their companies. These issues are becoming more critical as the cost, complexity and rate of technology change increase, and competition and sources of technology globalise. The management of technology for business benefit requires effective processes and systems to be put in place to ensure that the technological resources within the organisation are aligned with its needs, now and in the future [8]. As the organizations develop, an orchestration is required in order to define, collect, manage and improve the activities related with technology, which is TM.

Although TM has aforementioned advantages, the task of integrating the TM into businesses has become a complex and challenging step to overcome. For this purpose, in accordance with the needs of the organizational structure, existing processes within the organization, market requirements in the current sector, technological competencies, core and critical technologies needs to be assessed to be able to define all of the relevant TM components.

2. LITERATURE REVIEW

The tools of the TMF such as; technology radar, S curves, road-mapping, patent analysis, technology readiness levels in relation with a technology taxonomy, asset libraries, portfolio management, licensing, etc. has been studied and provided in [1-3]. It would be fair to say that there is not a common toolset or a defined framework that could be taken as a benchmark. Therefore, selection of TM components will be a tailored step that companies will have to experience solely; in accordance with the company goals, expectations after TMF definition, the business innovation level that they would like to get into.

US National Research Council (NRC) team has also defined the key elements of technology management [2], which served other researchers to build the models of technology management. These keys elements of the TM are:

- identification and evaluation of technological options
- R&D management of and the determination of the feasibility of the projects
- integration of technologies into the organization's activities
- implementation of new technologies in products and/or services
- obsolescence management and replacement of technology;

including five major activities in the field of technology management of in an enterprise, among which it is possible to distinguish as;

- identification,
- selection,
- acquisition,
- operation and
- protection of technology.

Roadmaps can take various forms, but the most common approach is encapsulated in the generic form proposed by EIRMA (European Industrial Research Management Association) (1997), which is Market, Product, Technology and Research and Development (R&D) and the STAR® methodology. The generic roadmap is a time-based chart, comprising a number of layers that typically include both commercial and technological perspectives. The roadmap enables the evolution of markets, products and technologies to be explored, together with the linkages between the various perspectives [6].

3. TMF METHODOLOGY

3.1. Approach to TMF

HAVELSAN is an IT(Information Technologies) and systems company providing global solutions in the areas of defense and IT sectors, and expanding its expertise in the fields of C4ISR(Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance), Naval Combat Systems, Air Defense Systems, Management Information Systems, Simulation and Training Systems, Homeland Security Systems and Energy Management Systems. Through his expertise, HAVELSAN focuses on the analysis, design, development and integration of large-scale systems in operational areas and in the fields of information and communication technologies, together with system integration, developing cost-effective integrated systems which transforms data into information as powerful instruments for decision-makers.

Elements that create the company policy of the investigated enterprise are focuses on four main areas, describing; competitiveness, creativity, stakeholder satisfaction, ethical values.

On the basis of a critical analysis of literature, a questionnaire was developed, which is then carried out in the form of direct interviews with representatives of the managers and related personnel. The current HAVELSAN strategies and processes have been examined with more than 300 hours of workshops and trainings over 10% employees for successful integration of TM processes into company structure. Conducted research allowed identifying a number of primary factors influencing in

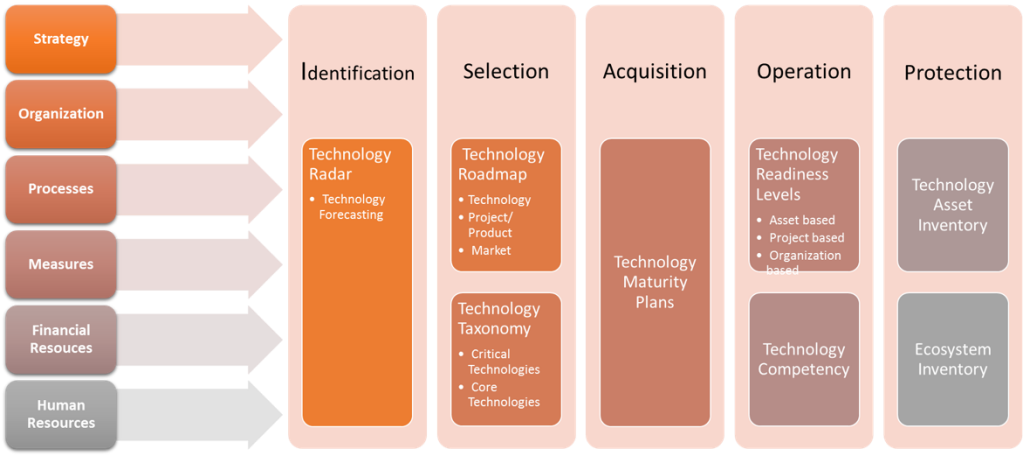
the way of the technologies management in the medium to big sized enterprise of the defense industry. As a result of inquiries, the routine process of developing solutions in the enterprise can be distinguished by the following activities:

- analysis of the possibilities of realizing the customer expectations
- identify the technological possibilities available in the market
- the selection of technology which will be adapted in the enterprise
- verification of selected technology with self-invested R&D projects prior to solution development
- obtain financial resources for R&D projects in relation with current financial charts
- train and adapt employees via R&D projects in the use of the technologies
- apply the newly adapted technologies for specific customer production requirements, through the execution for the proper realization of the solution
- search for new possibilities of application the technologies adapted with the other available projects

The results of internal analysis states that the driving force for HAVELSAN definitely looks as satisfaction of current customers, which is military forces herein, with breakthrough technological solutions. To have a controlled and measured TMF, using the five major activities of TMF defined by US NRC, the HAVELSAN TMF and the related tools and components of it is positioned as given in Figure 1. In this depiction, supplying TM activities with company's strategy, organization, processes, process measures, financial and resources planning activities is the key issue to have success in the transformation. In order to achieve this purpose, a major effort of analyzing the current technologies, capabilities already acknowledged and rapidly create new, and alternative efficient solutions will be the challenge.

In Figure 1: HAVELSAN Technology Management **Framework**, the components of HAVELSAN TMF are defined in accordance with 5 major TM activities defined by US NRC. These tools will be clarified further more herein in a relational manner in the following sections.

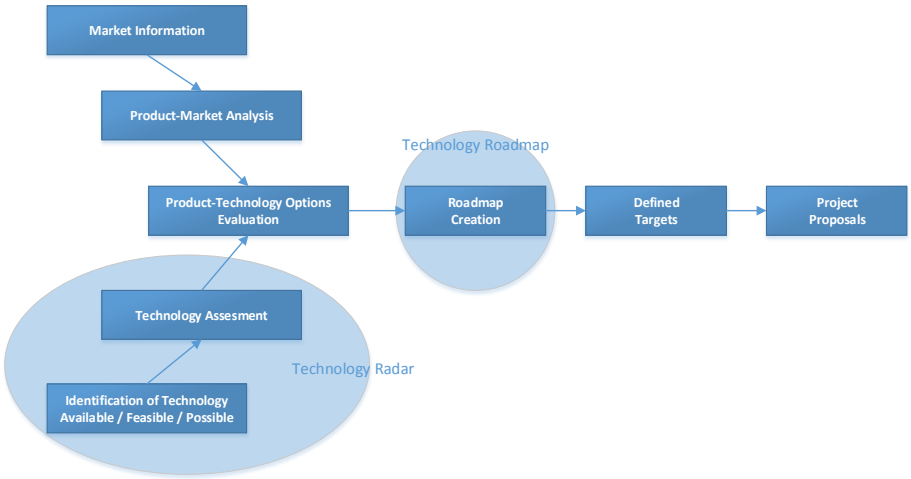
Figure 1: HAVELSAN Technology Management Framework



3.2. Identification

Identification and selection of technologies become the focal, integrating device for carrying the business strategy and planning process forward, bringing together the market/commercial and technological knowledge in the business (Figure 2) [6].

Figure 2: Roadmaps integrate commercial and technological knowledge (EIRMA, 1997)



3.2.1. Technology Radar

Technology forecasting and foresight estimates the future value of characteristics and performance of a technology. Since technologies are embedded in products, different measures of these products can be used in technology forecasting. Two classes of data play a central role in technology forecasting studies. In the first class, publications and patents are commonly excepted measures as indicators of scientific and technological performance. The second class is the performance data of the "technology in use" [5].

Technology Radar is the tool for identification of applicable technologies to HAVELSAN's solutions. With an exterior analysis; using both patent databases, competitive analysis, current technology forecast reports, in relation with company strategies promising area of interests are defined. The aim is to combine and store various findings from all environmental scanning activities on a central platform and represent near and far future set of potential technologies in a user friendly way for upper management to assess sustainable investment or make-buy decisions.

3.3. Selection

3.3.1. Technology Roadmap

Technology Radar gives an insight about where the technological enhancements are located and how big is the change and the dissemination rate of the technological trends. But elimination from this technology portfolio to drive organization' subset is subject of Technology Roadmap. This activity is more than complicated as defined in [7]; but to summarize it mostly depends on financial, strategic decisions of organization together with technology and market assesments which identifies the organization' orientation.

For such a critically positioned company like HAVELSAN, certainly there was a Technology Roadmap, but it was mostly a list of projects with a timeline.

In HAVELSAN Enhanced Technology Roadmap, the technology layer is in relation with technology taxonomy modules of TMF. The current technology readiness levels (TRL) of organization, and the related technology development R&D initiatives with the TRL goal, critical technologies and core competencies are represented. The technology demonstration projects and planned products could also be seen in relation. At the top, the new potential market size and customer, competitor landscape, targeted market size, product launch time, duration period of market presence, etc. kinds of information is also achieved from HAVELSAN Enhanced Technology Roadmap. The structure that is adopted for defining the layers and sub-layers of the roadmap is important, technology competencies defined in 3.5.2, financial limitations, risks, gaps, key decision points, knowledge barriers, key enablers etc. are also represented.

If past and current status of HAVELSAN TRM evaluated, it is clearly said that HAVELSAN TRM is leveled up from 1 to 3; in accordance with [7], Alignent Maturity Model (WWW.ALIGNENT.COM)

3.3.2. Technology Taxonomy

Technology taxonomy is important as it is used to define a common organizational understanding on technology descriptions. It is the basic technology thesaurus, in a defined level of depth and detail for managing overall technology operations of company. It is different from Technology Roadmap because taxonomy includes both core technologies that were already used in main businesses and the critical technologies that needs to be acquired in the future. The inputs from Technology Radar is flowed down to organization's interiors via Technology Roadmap, but Technology Taxonomy includes each and everything that organization already have or will have. Technology taxonomy is the key connection point, for the use cases of TMF and also the other processes such as project management, product development, acquisition, etc. within the company.

For HAVELSAN, there is a need to allocate hardware and software component level to certain technologies and to measure the changes in development cycle in means of TRLs. This need, is concluded with a certain level of depth – four levels-, but expandable in width. Finally, HAVELSAN Taxonomy is structured with;

- 12 main, 75 secondary technology areas
- Depth in four levels
- Width in averagely five hundred levels

3.4. Acqusition

3.4.1. Technology Maturity Plan

Technology acquisition is the set of activities done after defining the goals. Everything done in order to achieve the goals are studies such as; ideation, the proof of concept, technology demonstration, applied R&D activities, and the demonstrations within a system or a product. These activities are mostly related with projects or productization phases, therefore for the projects or products defined in technology roadmap, it is essential to track the outcomes.

Technology Maturity Plan (TMP) is developed for this purposes originally by HAVELSAN in order to define the goals of technology demonstration projects. The activities to be done for successful completion of project, key milestones, TRLs evaluations, technical performance measures (TPM) or success metrics and the goals to be achieved to declare that project concludes with expected outcomes are all defined in this plan. TMP is the starting point for acquisition that needs to be monitored and assessed within the whole life cycle of development until full mission of operation completed together with customer.

3.5. Operation

There is two aspects of gain in technological developments. First, is the progress achieved via work product; second is the employees' knowledge capability changes during the operations. TRL's are the measurement aspect of the first, which is work products; competencies are measures for personnel's level of technological know-how.

3.5.1. Technology Readiness Levels

As known, Technology readiness levels (TRL) are a method of estimating technology maturity of Critical Technology Elements (CTE) of a program during the acquisition process.

In HAVELSAN TMF, TRL's are positioned as measures of outputs or work products in relation of Technology Taxonomy. That means, for all technologies included in taxonomy has a measure of readiness level defining absorption level of technological capability. For TRLs to be calculated and verified, output criteria were tailored for HAVELSAN, align with the organizational processes and templates. TRLs were assessed in three different levels to have a measure on technological gains gathered via work products.

- Project level TRLs were measured in the beginning and at the end of the projects to assess the overall technology achievement of specific technology taxonomy element within the project. The purpose was to maintain the technical risks in the projects. Technology Maturity Plan's is the way of tracking this level of TRLs.
- Organizational level, that is the overall status of the organizations domination on a specific technology, was derived from projects outputs.

3.5.2. Technological Competencies

While starting to measure work products, the employees' competencies were also raised up as a new attribute that needs to be measured as technological competencies (TCs). It is obvious that while having a high level of TRL with a certain

technology and product, it does not mean that, company is eligible to develop it again in the case of a loss in the resources or know-how. Or similarly, in case of a high competency level on resources does not mean that he/she will be available for a certain technology development project. Independently from TRL, competencies are a measure on achievement of technologies on human resources basis, which needs to be planned, assessed and managed regularly. Therefore, TCs are a measure of technological know-how on the employees that will be the power or the weakness of a specific topic to be implemented in the work products. This parameter will be managed in relation with Human Resources Management discipline, in order to get ready for future resource management.

TCs are important and needs to be assessed, but to measure a level of know-how for a specific technology will not be accurate, if you do not take domain expertise into consideration. Therefore, application domains of technologies are raised up as another attribute of taxonomy that needs to be taken into consideration. The difficulties of TC calculations are; it's a subjective evaluation of management, there needs to be a defined scale of evaluation which is always subject to discussions, calculations needs to be repeated in a periodic basis and as mentioned, domain expertise needs to be considered.

3.6. Protection

When the operational activities within the project/product development completes, there are quantitative and qualitative outputs in place. These are assets that needs to be evaluated, restored, classified, and reused wisely for investments to be returned efficiently.

In protection phase, of course there is Intellectual Property Rights (IPR) subject as a huge activity to be considered. But herein this paper, details of IPR will not be given, as it is another area of expertise.

3.6.1. Technology Asset Inventory

Technology Asset Inventory (TAI), is a database includes the outcomes of the research&development activities. Main purpose of developing this database is for reusability purposes. Hardware/software components, subsystems/systems, algorithms implemented, white reports that has some kinds of analysis, models that are simulated are subject to TAI database. In other words, it is the HAVELSAN's open source library that everyone has access and right to both deploy and use.

The critical attributes of each asset is; Technology taxonomy correlation, TRL evaluation, ownership, source of the asset (Project/Product name), driven effort (man-month or line of code or etc.), maturity or quality of the asset.

3.6.2. Ecosystem Inventory

During the technology acquisition process, all of the organizations are interacts with others; similarly systems includes dependencies to outsourced components. Or more openly, there could be transfer of technology with sharing in the responsibility with partners. For such cases, technology providers and their capabilities also needs to be evaluated, restored, classified, and reused. This step makes organizations more agile and competitive in today's fast developing technology revolution. Especially for defense companies such as HAVELSAN, developing large-scale systems, an improved technology provider ecosystem is a must.

In means of TMF, differently from supplier management systems, and standard quality management system evaluations, TRL level assessments are taken into consideration for technically approved suppliers to be in the loop. For this purpose, first of all technology suppliers are differentiated from the others, than supplied products or services are correlated with technology taxonomy and measured with TRLs, this TRLs are evaluated in accordance with HAVELSAN's output criteria and lastly these data are stored in Ecosystem Repository for future uses.

4. FINDINGS AND DISCUSSIONS

In this section, other attributes of TMF are defined; such as schedule, goals, milestones; what had been completed so far and what are the goals for future work. The issues, risks, assumptions and constraints will be evaluated herein further for bodies that are interested or already applying such factors into their business. Unresolved subjects, affected processes, the reasons of tailoring, unexpected changes that we had passed on the road will be analyzed. Also the organizational and the process wise dimensions and limitations will be clarified.

The HAVELSAN TMF definition processes to achieve a defined and measurable output, tools and components of TMF, the unique ways of integrating TM components are identified in this paper. The derived TM Process flow is given in Figure 3: HAVELSAN Overall TM Process **Flow**. This flow clearly shows the inner and outer dependencies of process. R&D, innovation, strategy, finance, HR, project planning and development, ecosystem management are the most critical predefined

processes for TM. For TM use cases to be applied to the whole project/product development life cycle, the interactions of these processes are managed via more than 30 Document Change Request (DCR) to the current system.

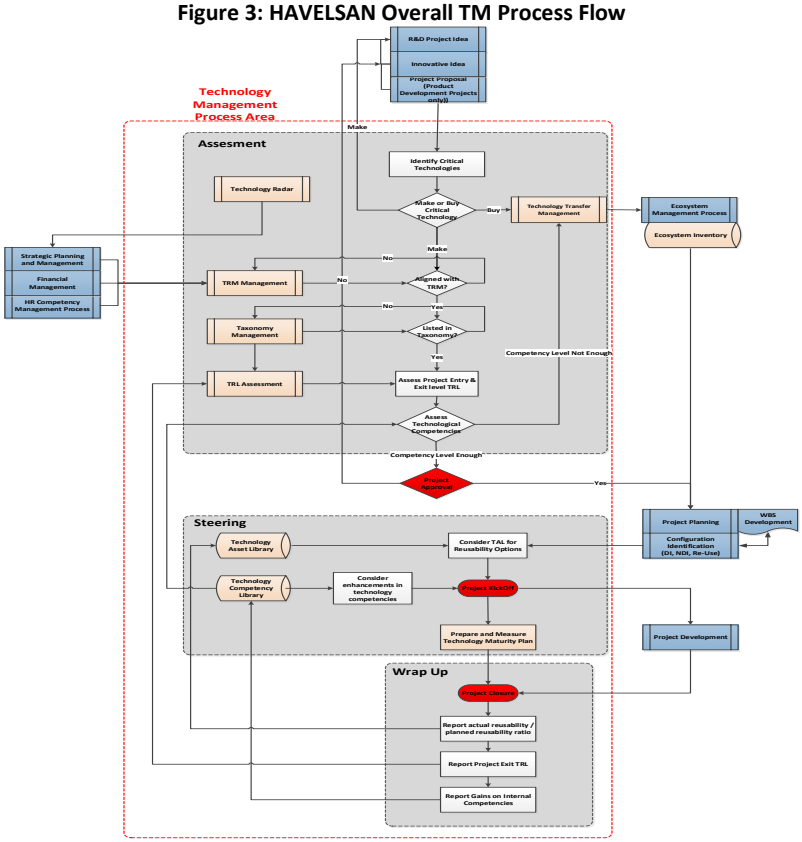
The whole prosess is divided into 3 sub processes, as; assessment, steering and wrap-up. Assesment phase includes more strategic activities to decide "what to do" in accordance with technologic intelligence collected, TRM comformity, technology taxonomy compliance, make-buy decisions, technology transfer possibilities etc. Steering phase, consists of "how to do" activities after project kick-off, such as planning the technologic achievements, evaluation of reusability oppurtunities, definition of success criterias and technical performance measures, TRL goals, etc. Wrap-up phase is the collection of all the outputs in means of technology competencies, accomplished TRL levels, and tangible outputs of the project which are subject to TAL.

By this process flow given in Figure 3: HAVELSAN Overall TM Process **Flow**, triggers such as innovative ideas, R&D proposals, and contracted projects are considered and managed in line with whole project life cycle.

The definition of TMF within HAVELSAN is managed as a transition project of five quarters, starting from the second quarter of 2016, which we are in the fourth quarter of it. The TMF Transition Project (TMFTP) includes the following activities;

- Constitution of a working group from all related departments of organization, such as HR, Finance, Engineering, Purchasing and Acquisition, etc.
- External and internal analysis,
- Definition of TMF and its components,
- Developing the processes related with TM,
- Evaluation of current HAVELSAN processes and making the necessary changes on them,
- Definition of KPIs and metrics of TM,
- Definition of additional roles, responsibilities, evaluation boards and organizational structures
- Automization of TMF tools and use cases as much as possible

Figure 3: HAVELSAN Overall TM Process Flow



Other than the automization task of TM tools and use cases, all the other tasks are completed. The TM process started to be run in the company since last two quarters. But of course, there are issues and improvements that needs to be recovered.

Analyzing the advantages of TMF, reporting the gains and losses after the TM activity will be a major step to be achieved. Especially for upper management, as sponsorship, all the measures of the TM and related KPIs are alredy defined. But, as collection of measurement data is a time consuming activity, a period of time for enough sampling is required.

The most challenging step was the resistance to the change. To change the processes derived from military standards was also a huge step such as raising over thirty document change requests to the system. To overcome this issue, a working group was established. This group of people was attended to all the workshops, discussions and necessary trainings, who are then used as technology agents within the organization for dissemination of information for the rest of the company.

Two newly defined boards and a new role is defined in order to ensure the process as control points. Technology Control Board (TCB) is mainly tracks, ensures and reports the operations done mostly in engineering departments for in-house assessments to understand the current position of company. Technology Management Board (TMB) is mostly a strategic decision authority for technologic alignment. There is still a need for a new role of technologists, as agents of TM within the organization to fulfill the necessities of TM phases.

The activities undertaken in the implementation of process management technologies in enterprises generally proceed in a linear manner, to minimize the time of its introduction, providing the enterprise a competitive advantage and increase the production capacity. But, some pilot activities are needed to be activated before baselining the processes, since results or reaction of the assumptions to be verified. These pilot activities needs to be attentively defined, placed and controlled for the successful operation.

As a future work, all TM tools will also be automized in an organizational management software tool, with inner and outer process dependencies. The outputs of the new TM system will be shared comparing with the older results as a future work, together with the challenges that had been faced during the transition project TTMP, which makes this work to be business model innovation.

5. CONCLUSION

The technology management in an enterprise largely depends on the size of the company and its organizational structure. It takes place at the level of executives management, but substantially supported by technologists and technology agents. Not without significance are issues of the economic viability of implementation the new technologies, as well as the possibility of adapting these technologies into enterprise development/production, and as a result the possibility of long-term exploitation of the technology.

We hope this case study will be guidance for similar companies, who also aims to have a big step up to management of technologies, in the rapidly changing technology evolving environment. It needs to be remembered that, definition of a TMF in an organization is a unique step to be achieved solely. For this purpose some level of consultancy might be taken into consideration for the process to be expedited.

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