



A technology readiness levels (TRLs) calculator software for systems engineering and technology management tool

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ABSTRACT

Turkish defense industry and policy makers seek effective and successful system development programs by implementing a validation mechanism to verify the maturity of new technologies being developed in national laboratories and industry. Technology Readiness Levels (TRLs) developed by NASA as a general metric of technology advancement and it has been widely accepted as a systems engineering and technology management metric tool. In order to explore the sufficiency of this tool, first of all, academic and applicable studies of army and civil organizations have been searched out and the lessons learned have been analyzed in this study. Thereafter, questionnaires of awareness of TRLs and TRL Calculator have been applied to defense firms in Ankara, and interviews held with the technology developers, firms' speakers and defense authorities. Finally, the applicable algorithm of TRL calculator has been recommended for Turkish defense industry.

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1. Introduction

Different classifications of technology has been emerged in the literature for years; however, classifications became more complex in the last decade. Diversity of technologies, complexity of systems and knowledge-based programs standing out with their huge budget, and many scientists and technologists draw attention to controlling and developing new technologies based on the needs. From this point of view, technology management science may need to be re-organized by merging both analytical and experimental processes.

Technology readiness assessment (TRA) is a consequential process to select the best technologies meeting the system requirements by examining maturity of the technology. Working through the TRA process, some more details must be observed such as organization, system, subsystems or components and procedures of national defense development policies. As a lesson learned through the system development programs, the technology must be mature before system development begins [1]. Mature technology is tested in a relevant environment and it must be achieve the threshold measurements convenient for intending mission. Imma-

ture technologies are the main sources of problems on weapons system programs [2].

Technology Readiness Levels (TRLs) is accepted metric system for measuring the maturity of technology DUSD S&T (Deputy Under Secretary of Defense, Science and Technology), US National Aeronautics and Space Administration (NASA) and AFRL (Air Force Research Laboratory) for years. TRL is used as a beneficial metric system by program managers and technologists in many defense system programs. However, there are several problems of measuring maturity effectively and objectively by using TRL Calculator developed by AFRL, and approaches linked to the maturity measuring systems are differentiated among the constitutions and countries.

This paper proceeds as follows: Following the introduction, second section examines the TRLs systematic; Section 3 includes a brief view to Turkish Defense firms' awareness of TRLs and in Section 4 there is a recommendation of TRL calculator algorithm and new features in this calculator are discussed.

2. Technology maturity and TRLs

Technology has a life cycle observed through the growth, maturity and decline, this process is characterized by S curves [3] in Fig. 1. Technology maturation stages may be discussed in terms of years and commercialization capability, these factors linked to

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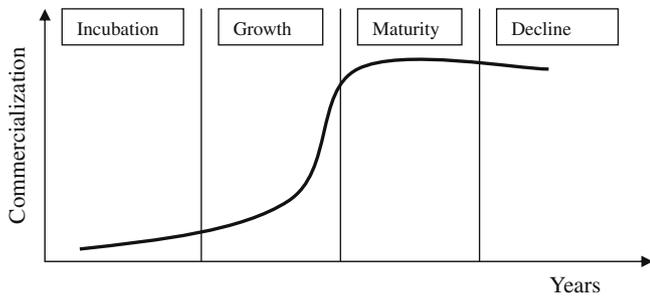


Fig. 1. Characterization of technology maturity process as S curve.

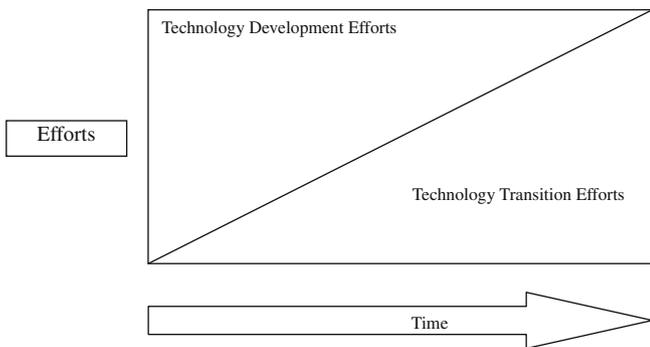


Fig. 2. Technology transition process and technology development [5].

the knowledge, R&D efforts out of the laboratory and competitive advantage of technology.

A system consists of subsystems and technologies that are developed within system development process or independently. Generally, in defense system programs, specific technologies developed within system development process, technology transition is a major process to establish the technology and system development improve together successfully.

Technology transition is the process by which technology deemed to be of significant use to the operational military community is transitioned from the science and technology environment to a military operational field unit for evaluation and then incorporated into an existing acquisition program or identified as the subject matter for a new acquisition program. This is different from technology transfer, which is a technology partnership between government and industry by means of which, technology developed by one party is transferred to the other party for development and use, often with residual rights to the transferring party. The government may develop a technology in one of its labs and transfer it to industry, the government holding rights of some kind to the developed products. The objective of technology transition is to make the desired technology available to the operational units as quickly as possible and at the lowest cost [4]. Technology transition process must be start in time of technology development program starts.

Technology development takes great efforts more than technology transition process when the system development program begins; however through the end of the program, this situation changes as transition efforts become greater Fig. 2 [5]. Therefore, technology readiness becomes critical for integration of the technology with the system and for investing the technology development process. Technology readiness has great importance to analyze the risks in the system development process and Technology readiness levels (TRLs) have become the de facto standard technique used to assess the maturity of new technologies as a

means of evaluating their readiness for incorporation in new systems [6].

According to GAO (US General Accounting Office) report once the readiness level of the technology has been established, the risks of including that technology in a product development can be assessed. Unlike science and technology projects, for which the main objective is to develop knowledge, a product development's objective is to deliver products that meet strict cost, schedule, and performance targets [7].

Technology development process consists of nine levels. In defense projects, project managers generally select the technologies at TRL 6 or higher levels and the lower maturity of the emerging technology is not preferred since the greater effort is required to raise that technology to a readiness level suitable for its inclusion into an acquisition programme [8]. Summary of TRLs can be shown as in Table 1 [9].

NASA instituted this nine level metric as a systematic metric/measurement approach to assess the maturity of a particular technology and to allow consistent comparison of maturity between different types of technologies as materials, hardware components, software components and devices. However, there is no standard repeatable method for determining the TRL achieved by a given technology, except Air Force Research Laboratory (AFRL) Excel-based US TRL Calculator prepared by William Nolte. Questions have been prepared by James B. Bilbro.

The TRL Calculator is a tool for applying TRLs to technology development programs. In its present form, the calculator is a Microsoft Excel spreadsheet application that allows the user to answer a series of questions about a technology development project. Once the questions have been answered, the calculator displays the TRL achieved. Because the same set of questions is answered each time, the calculator provides a standardized, repeatable process for evaluating the maturity of any hardware or software technology under development. The calculator provides a snapshot of what a technology's maturity level was at a given time.

The TRL Calculator can be a useful tool in a risk management program. It can also help in the overall program management of a technology development effort because it tells management the current state of the program's technology maturation process. The calculator's questions and percent complete feature can assist a program manager in tracking progress toward accomplishing required tasks [10].

Technology readiness levels calculator is a subjective tool for exploring the maturity of the technology. TRLs are a uni-dimensional scale used to provide a measure of technology maturity; technology maturity is a multi-dimensional problem [11].

Currently, there is no standard or common used approach for implementing TRLs. Consequently, a process is needed that improves consistency (reliability) and efficiency of the application of TRLs [12].

Another issue to consider is that TRLs are currently defined for system Technologies but not for non-system technologies, such as processes, methods, algorithms or architectures [13]. AFRL TRL Calculator must have generic questions about these kinds of technologies.

Technology maturity has many dimensions as technology developers' opportunities, experiences, and the relationship with project managers, system parameters and characteristics of technology, etc. A TRL calculator should give specified data about technology developer and technology development process to the project manager. These data could be helpful for project decisions as technology selection, funding, system integration procedures, dates, and technological risks. Actually, the project manager's experiences, knowledge and perspective are not integrated into TRL calculator, yet this kind of calculator might be used to achieve the qualified and ordered data. Project manager can use technology

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