THE COMPLIANCE OF PROJECT MANAGEMENT WITH CORPORATE'S RESEARCH AND DEVELOPMENT STRATEGIES: DTI'S VIRTUAL SHOOTING RANGE CASE STUDY

Chamnan Kumsap

Defense Technology Institute (Public Organization), Ministry of Defense,
Office of the Permanent Secretary of Defense, Ban Mai, Pak Kret, Nonthaburi, Thailand 11120

chamnan.k@dti.or.th

ABSTRACT

This original article was aimed to share with military simulation and training community how the project management of a military simulation and training project named *'Virtual Shooting Range*' or *VSR* was carried out in line with corporate's research and development strategies. The B.E. 2551 *Royal Decree of the Establishment of Defense Technology Institute (Public Organization)* or DTI was quoted to reflect the strategies that follow the objectives, roles and responsibilities defined in the Royal Decree. The strategies were elaborated each in turn to give an idea that research and development projects of DTI have to include activities in order to align with the strategies. The activities of the *VSR* project were discussed in terms of compliance with the explained strategies. It further contributes to the project management community by introducing a *Double Pyramid* approach for non-profit organizations where knowledge and innovations are highly expected from the public. One of the achievements of the project was measured by research grant conferred to *DTI* by the *National Research Council of Thailand* in order for *DTI* to extend products of the defense technology research to a commercialized stage. Byproducts of the project apart from deliverable systems were adopted as a key performance indicator to demonstrate how this defense research and development project was managed to build knowledge and innovation, develop collaborative and cooperative network, and develop a sustainable organization in line with the strategies. The paper illustrates the activities carried out with partners and sectors outside *DTI* that were central to the philosophy of *DTI*'s existence. It concludes that the *VSR*'s research and development activities were defined, designed, developed and delivered to comply with *DTI*'s research and development strategies that helped to partially improve the national competitiveness in building the potential and capabilities of hardware and software industry.

Keywords: virtual shooting range, corporate strategy, project management, defense research and development

1. INTRODUCTION

The scientific and technological contributions of defense and military research in Thailand have recently been directed towards a commercialization and production stage. The research and development institute such as *DTI* was established to realize and achieve the goal. In *DTI*, the research and development strategies were formulated to define missions for *DTI* researchers to utilize available resources to conduct research and development tasks. The *VSR* project was used as a case study to showcase its imperatives for project management including managing the explorative phase, managing the involvement of stakeholders in the project, and managing the project in relation to the strategizing process of the institute (Ben Mahmoud-Jouini et al, 2016). The project management was planned to contain not only within the *Iron Triangle* (Atkinson, 1999) but also collaborative and cooperative network of key stakeholders that Atkinson (1999) proposed for the framework to consider success criteria, the *Square Route*.

This article reports how the VSR project management was planned and conducted in a manner that aligned with institute strategies and had the public informed in various channels. It further contributes to the project management community by introducing the *Double Pyramid* approach for the planned research and development activities in response to public expectations provided that the activities were carried out within non-profit organizations where knowledge and innovations are highly expected from the public especially on the project of huge budget investment. Numerical investigation on the proposed equations, however, is needed further to validate the approach and equations. Due to the fact that the *VSR* project management created partnerships and research network that involved individuals, the descriptive and illustrative report of the article was limited to contents that were not to violate individual rights and not to expose corporate confidentiality agreement. It was assumed that the project management of research and development activities that complies with corporate strategies would benefit defense and military research projects, reinforce national defense and security measures, and improve the national competitiveness in a scientific and technological domain at an international stage.

ISBN 978-88-97999-90-4; Bruzzone, Cayirci and Sottilare Eds.

2. DTI RESEARCH AND DEVELOPMENT STRATEGIES

2.1. Strategy 1: Research and Development of Defense Technology

The goal of this strategy is to improve the capability of the ministry of defense by means of research and development of advanced defense technologies to achieve the output of weaponry prototypes. It is envisioned that domestic industries will be able to support relevant logistics and indigenous human resources for the selected weaponry prototype. The research and development take into account the strategic context of the nation and the region. This strategy encompasses the research and development of core defense technologies and how to transfer knowledge and technologies to the industrial line of production.

2.1.1. Research and development of core defense technologies

DIT identified eight core technologies for its research and development. Four technologies including *Rocket & Missile, Military Simulation and Training and Information and Communication Technology* and *Unmanned Vehicle System* were approved by the *Defense Ministry Council* for research and development. Other four technologies wait for the approval from the council.

2.1.2 Transfer of knowledge and technologies to industrial line of production

The process to realize the research and development to defense industry is believed to take 10 steps as illustrated in Fig. 1. An initial phase includes Steps 1 to 4 where an analysis of user requirements, feasibility studies for master plan, council approval for the master plan, and proposal for project and budget approval are conducted. Steps 5 to 7 are research and development that involve the interface with the armed forces in a regular basis to keep users in the loop.

2.2. Strategy 2: Development of Knowledge and Innovation to the Public

The goal of this strategy is to develop, to store, and to acquire defense technology knowledge in a continuous and sustainable manner. The knowledge is to be transferred to the public for exploitation via academic, commercial, and industrial sectors.

2.2.1. Development of defense science and technology knowledge

There are two different approaches of developing defense science and technology knowledge. The first one is conducted in-house by DTI researchers in form of basic research and applied research. The second approach is achieved by either subsystem procurement from industrial partners or research engagement with academic sectors. The academic research engagement is managed by hiring professors in relevant fields of expertise to build subsystems.

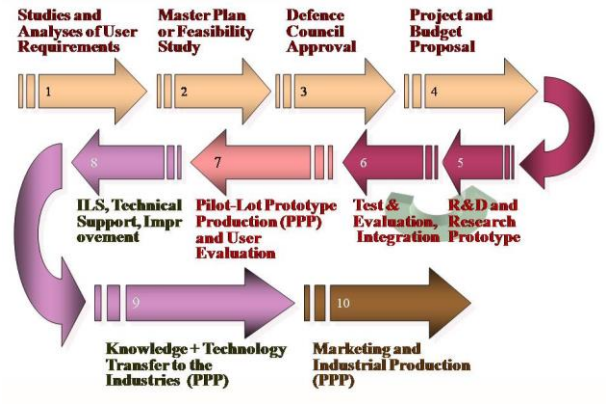

Figure 1: Steps from defense research and development toward defense industry

2.2.2. Human resource development of defense science and technology

Human resource development encompasses academic research engagement and direct human resource development in short training courses. Grants are provided for a research proposal in relation to DTI's core technologies. The master degree of defense engineering is also provided for individuals seeking higher education.

2.2.3. Management of defense science and technology to the public

The knowledge as the result of research and development is managed publically in two ways. The first one is in form of knowledge management prior to publication. Target users for this knowledge management are industrial and commercial sectors who have an agreement with DTI and intend to commercialize or invest in the project's line of production. The second way of knowledge management is in form of research papers for national or international journal publication, national or international conference proceedings, research and technical report, classified pieces of work procedures and instructions, and other writings for magazine or internet publications. National and international recognition and acceptance are built upon this knowledge management.

2.3. Strategy 3: Development of Collaborative and Cooperative Network

The goal of this strategy is for the *Ministry of Defense* and the country to manage and make utmost use of the knowledge and resources of defense technology from formally established network in an effective and efficient manner.

2.3.1. Development of common policy and vision

Agreement is in form of contract after fair and transparent bidding that can eventually lead to signed memorandum of understanding that defines in general the common policy and vision of the two parties toward the specific research and development project. Where domestic corporate and private sectors lack specific

capacity for a given project, foreign partners are invited for technology demonstration via formal invitation or letters with the attention made to the *DTI* director. Non-disclosure agreement is basically reached before further agreement or commitment.

2.3.2. Development of cooperative and participative mechanism

A mechanism that key stakeholders within the ministry of defense can cooperate is developed at the initial stage of drafting the core technologies' master plan. That is to ensure the involvement of users from the *Royal Thai Armed Forces* to define projects for *DTI* researchers to carry out, to identify what military units to validate the product by means of test and evaluation, and to input military doctrine that is central to the design phase of the defense research and development.

2.4. Strategy 4: Development of Sustainable Organization

The goal of this strategy is for *DTI* administration to follow good governance policy of the government, for *DTI* researchers to perform efficient research and development and to attain excellence in core defense technologies, for *DTI*'s transparent logistics and support, and for *DTI*'s self-learning environment and sufficient research and development infrastructure.

2.4.1. Development of financial affairs

In the *Royal Decree of DTI's Establishment*, the Article 2 Code 8 (6) states that *DTI* has roles and responsibilities for charges from fee, maintenance fee, remuneration or services under regulated criteria and rate. *DTI* has ordered the regulation to support incomes of the charges without having to return them to the Ministry of Finance under the *Article 2 Code 10*.

2.4.2. Responsive development to user satisfaction

Apart from the initial stage of the research and development that user requirements are included in conceptual and detailed design. Logistics and schedules for test and evaluation are attached to the service plan to keep track on functionality and performance of the delivered system. Contact data of suppliers responsible for integrated subsystems is stored for later logistical services and maintenances.

2.4.3. Good governance for internal affairs

DTI is subject to regular performance assessment from a lawfully registered body that is deemed expert in the field. The result of the assessment is liable to reveal evident facts in terms of the effectiveness and achievements of corporate development and others specified by *DTI* board of directors.

2.4.4. Development through learning

The *Royal Decree Article 1 Codes 7 (3), (4),* and *(5)* require that *DTI* cooperate with other state agencies, academic sectors and domestic and international private sectors in defense technology. In addition, *DTI* is required to support trainings, to encourage research, to develop human resources in defense technology, to act as the center for the service of defense technology data and information, and to facilitate academic activities for the purpose of the dissemination of defense technology knowledge.

3. THE COMPLIANCE OF *VIRTUAL SHOOTING RANGE*

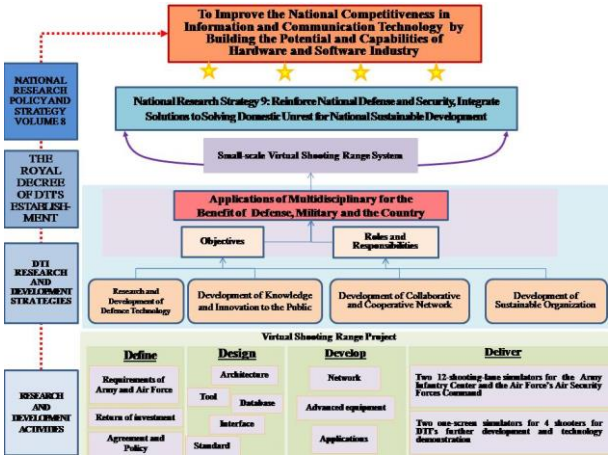

Figure 2: The compliance of *DTI's VSR* and *National Research Policy and Strategy*

3.1. Overview of the Project

The *VSR* project was the first one under the *Military Simulation and Training Master Plan* (see Fig. 2). The research and development activities were planned and managed to correspond to the institute strategies that follow closely the objectives, roles and responsibilities of *DTI*. Within two fiscal year *time*frame and a little over 1 million US dollar *cost*, the project was required to arrive at four training simulators that were ready for *delivery* to the *Army's Infantry Center* and the *Air Force's Air Security Forces Command*. Further validation from both units was needed to complete the prototypes with desired *quality* and acceptable standard of test and evaluation. The project's two fiscal year duration spanned from October 2013 to September 2015. The output was expected to be economically viable due to the rationale that the prototypes were to be commercialized, in line of production, and partially compensating foreign import.

3.2. Research and Development Activities

The research methodology was viewed from a 4-D (*define, design, develop, deliver*) management perspective. Workshops and seminars were held to collect users' requirements prior to the launch of the project. Fig. 3 above shows one of the workshops under the title '*Virtual World and Training Scenarios: The Essence of Newly Advanced Technology*'. It was held at the Ramar Garden Hotel, Bangkok, Thailand during 17-18 September 2013, as a forum that facilitated exchanges and sharing of research and development activities from the *Air Force's Air Security Forces Command*, *DTI* researchers, and Thailand's university academia. The activity responded to all the strategies described in Sections 2.1, 2.2, 2.3, and 2.4.

3.2.1. Defining user requirements

Figure 3: The workshop that corresponded to all *DTI's research and development strategies*

3.2.2. Designing system architecture

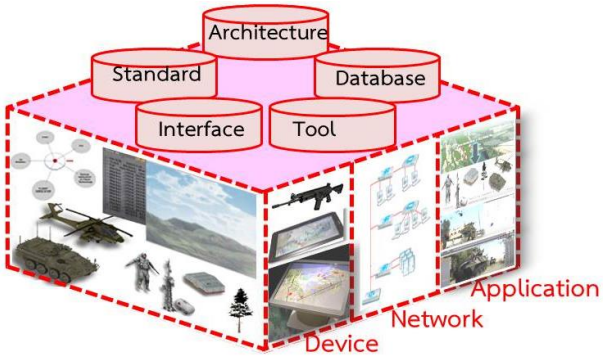

Figure 4: Five pillars of the projects of *DTI's Military Simulation and Training* Master Plan

The *Military Simulation and Training Master Plan* requires projects under it share the same pillars including *Architecture, Standard, Database, Interface, and Too*l (Kumsap and Meegla, 2013). The ultimate goal of this concept was to save cost of investment whereby each project will be able to share the existing infrastructure as shown in Fig. 4. Advanced and developed devices are the result of research and development activities that will house applications that match users' requirements, and to be networked with other existing simulators through shared and integrated *Architecture* (Kumsap et al, (2013) and Chieochan et al (2015)).

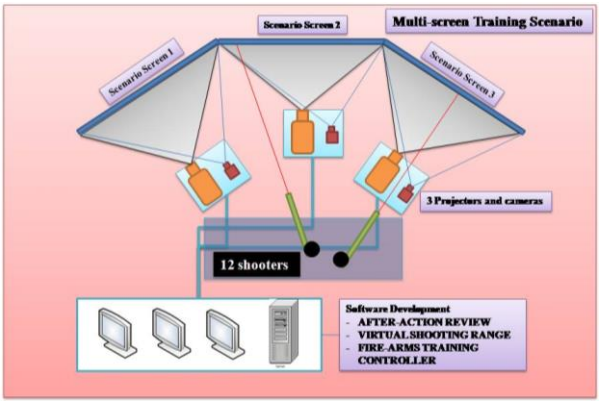

Figure 5: Conceptual Design of *VSR*

The *VSR* was conceptually designed as shown on Fig. 5 to interface main hardware devices including three scenario screens, three sets of cameras and projectors, twelve BB Guns for twelve shooters, three image generators, and one computer for instructor operating system. The software development included *After-Action Review, Virtual Shooting Range, Firearms Training Controller*. The activity mainly responded to the strategy described in Sections 2.1 that focused on the research and development of core defense technology.

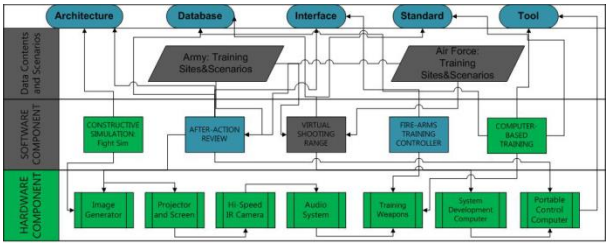

Figure 6: Detailed Design of *VSR*

The project's activities detailed in Fig. 6 are in three colors and geometric shapes. The green color represents collaboration in terms of purchase from and co-research with private sectors. The dark grey represents close cooperation with the *Army's Infantry Center* and the *Air Force's Air Security Forces Command*. The blue ones represent in-house research and development within *DTI*. The blue rounded rectangles are used for representing the research and development of military simulation and training technology since they resulted in establishing the foundation of the master plan. The green predefined process boxes ae used for representing the development of collaborative and cooperative network with private and public sectors. The green rectangles are used for representing the development of knowledge and innovation to the public. The dark grey parallelogram goes deeper to the development of cooperative and participative mechanism in which the *Army* and *Air Force* armed units that were central to the activities.

3.2.3. Developing system

The five pillars of the *DTI's Military Simulation and Training* Master Plan were utilized as selection criteria when choosing hardware devices for a system prototype. The standard of all the devices were strictly followed to ensure a seamless interface during system integration stage, see Fig. 7. A *Gun Recoil System* was vital to realistic firearms training, thereby being initiated as another research and development project in *DTI*, and more importantly responding to the Strategies of Section 2.1 and 2.2.

In order to network distributed simulators as *VPN Spoke #1* at the *Air Force's Air Security Forces Command* in *Don Mueang*, Bangkok (see Fig. 8) and as VPN Spoke #2 at the *Army's Infantry Center* in *Prachuab Khirikhan* province, there was a requirement to establish seamlessly networked communications. That was to be

ISBN 978-88-97999-90-4; Bruzzone, Cayirci and Sottilare Eds.

a good infrastructure for distributed simulation intended by the *Master Plan*. For data communication security,

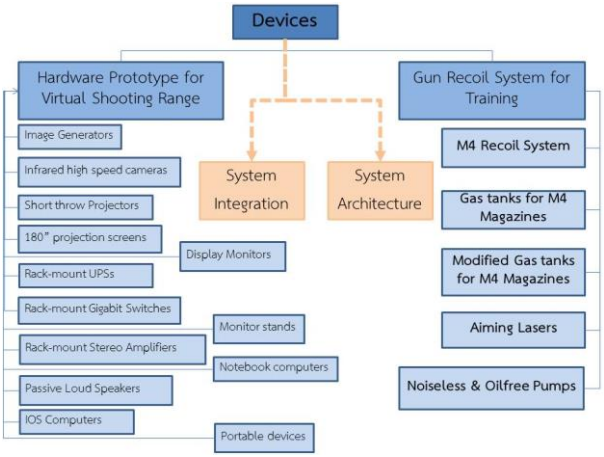

Figure 7: The importance of standard of devices for seamless system integration

the *Virtual Private Network* (*VPN*) was adopted as a central network under standard network-level encryption. The *VPN Hub* was at DTI with access to *Internet Cloud* and server for system monitoring. The VPN Spoke *#1 and #2* mentioned earlier were installed with access to *Internet Cloud* via 3G/4G.

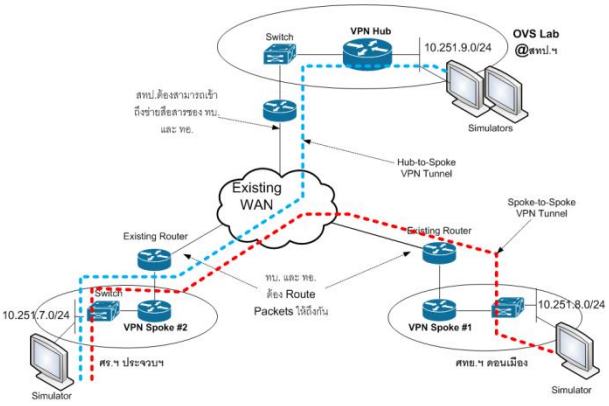

Figure 8: Dynamic multipoint *Virtual Private Network* (*VPN*) for distributed simulation over the Internet

Applications that run on the network include *training scenarios, after action review and computer – based training* illustrated in Fig. 9. The *instructor operation system* was each installed at the three nodes. The *training scenario development* answered to the Strategy in Section 2.1 on the research and development of *Military Simulation and Training* technology with the development of collaborative and cooperative network among DTI, academic sectors, the *Army's Infantry Center* and the *Air Force's Air Security Forces Command*. The *instructor operation system* and *after action review* component were complete in-house capability built upon the standard purchased tools with some input from the users. The *computer – based training* component was a collaborative work between DTI and Thailand's public university that signed the MoU with DTI. Military officers from the *Army* and the *Air Force* were source of system validation and user satisfaction.

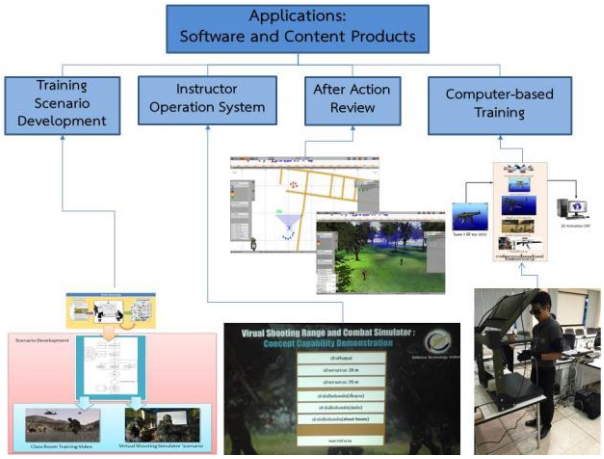

Figure 9: Applications of the *VSR* on the *Virtual Private Network* (*VPN*)

3.2.4. Delivering project output

Figure 10: *VSR* installed for test, experiment and use in the *Army's Infantry Center* (upper left and middle right) and the *Air Force's Air Security Forces Command* (middle left and lower)

The complete system of software installation, hardware implementation and integration as conceptually designed in Fig. 10 was delivered to the *Army* and the *Air Force* at the end of fiscal year 2015.

For the validation purpose, the delivered systems were validated in three categories namely system test of evaluation, software validation at the installation sites and *ISO/IEC 29110* at *DTI* (see Fig. 12). The first two were aimed at testing system's seamless integration, functionalities and response to users' requirements in terms of training effectiveness and representation realism and consequently responded to Section 2.4.2. The complete manual of the project validation of the *VSR* was reported in Haddawy (2016). The third one

was to ensure that the research and development team in *DTI* complied with the *ISO/IEC 29110* in project management software implementation and the project team has recently filed for the *ISO/IEC 29110* certification.

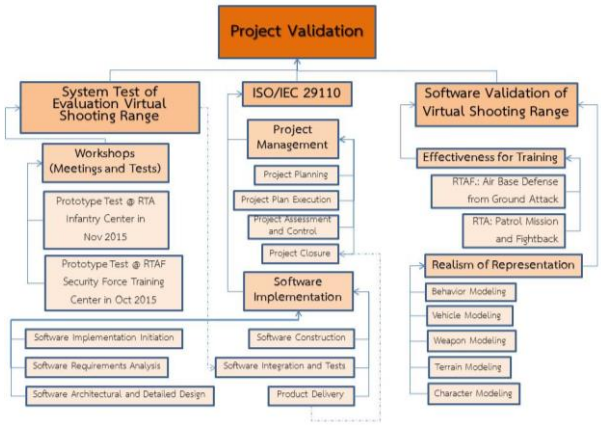

Figure 11: *VSR* project validation

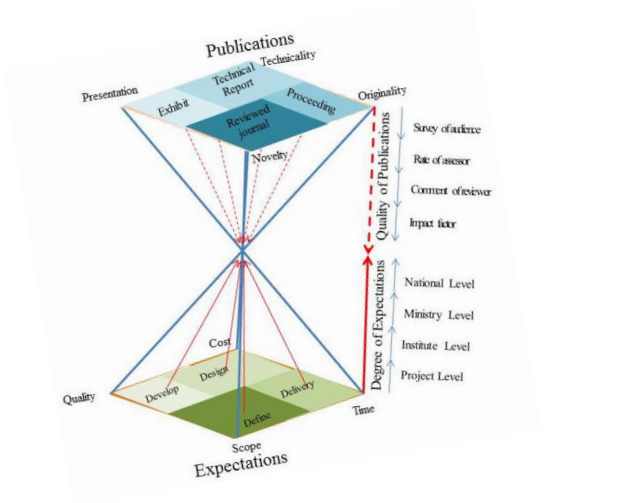

Figure 12: The *Double Pyramid* approach to cope with expectations for non-profit organizations

Two one-screen simulators for four shooters were installed with one system in *DTI* for further research and development and the other one was used for technology demonstration in related defense exhibitions (Fig. 13). This simplified and economical system architecture received research grant from the *National Research Council of Thailand* (*NRCT*) in order for *DTI* to extend products of the defense technology research to a commercialized stage. The architecture was designed to get a concise, yet, effective portable system that made it easier for only one person to carry, set up and operate and then called the *economy scale architecture* of the *VSR*. This research grant proved that the *VSR* complied with the strategy in Section 2.4 whereby the grant helped *DTI* to develop financial affairs of generating incomes and to continue developing the *VSR* according to an objective of the grant.

4. PROMOTING PUBLICATIONS TO COPE WITH EXPECTATIONS

Since the cost, time and scope of the *VSR* were fixed by allocated government budget, allowed fiscal years and signed agreements with the *Army* and the *Air Force*, the project quality was managed to keep the diamond in shape. The project was defined to respond to requirements of the *Army* and the *Air Force*, designed to stay within the budget allocation, developed with technologies that brought innovations, and delivered in time. The project needed to live up with strategically gradual expectations towards the tip of the *Double Pyramid* (see Fig. 12) where the improvement of national competitiveness (top of Fig. 2) in science and technology was expected by the public. To keep the equidistant diamond shape, the volumetric *Expectations* should be:

$$Exp = \frac{(Define+Design+Develop+Deliver)x\ DoE}{3} \quad (1)$$

where *Exp* = Volumetric *Expectations* at 33.33 maximum while performed *Define*, *Design*, *Develop*, and *Deliver* are in percentage of success as the project ends, and *DoE* = Degree of Expectations from four levels which is $\leq \frac{1}{(national+ministry+institute+project)}$, whereby *national = planned_national/performed_national*, *ministry = planned_ministry/performed_ministry*, *institute = planned_institute/performed_institute*, *project = planned_ project/performed_ project*, and each level can reach the maximum value of 1 where planned equals performed.

It can be seen from Fig. 12 that (1) can arrive at 33.33 units when each variable to the right hand side reaches their maximum value. The upside-down pyramid of Fig. 12 illustrates various forms of *Publications* that include *Exhibition*, *Technical Report*, *Conference Proceeding*, and *Reviewed Journal* shaped respectively by *Presentation*, *Technicality*, *Originality*, and *Novelty*. The project could live up to *Expectations* of the public and complied with the *Strategy 2* provided that the *Publications* were made equal to *Expectations.* Each publication must include in their content *Presentation*, *Technicality*, *Novelty*, and *Originality* to achieve high *Quality of Publications*. Just like the equation (1), the volumetric *Publications* should be:

$$Pub = \frac{(Exhibition+TechReport+Proceeding+Journal)\ x\ QoP}{3} \quad (2)$$

Where *Pub* = Volumetric *Publications* also at 33.33 maximum while measured *Exhibition*, *Technical Report*, *Proceeding*, and *Journal* are in percentage of achievement as the project ends, and *QoP = Quality o Publications* which is $\leq \frac{1}{(survey+rate+comment+impact)}$, whereby each *Publications* result can reach the maximum value of 1.

5. DISCUSSIONS

5.1. The Royal Decree of *DTI*'s Establishment

The compliance of the *VSR* with the *DTI*'s research and development strategies was evidently illustrated in Section 3. Objectives of the DTI establishment were fulfilled by the delivery of the *VSR* systems to the *Army*, *Air Force* and *DTI* and other collaborative and cooperative network built from within the project management. The project answered to roles and responsibilities of DTI in which it generated the MoU between DTI and the *Land Development Department* of the *Ministry of Agriculture and Cooperatives*, the MoU

between DTI and the Department of Special Case Investigation (DSI) of the *Ministry of Justice*, and the MoU between DTI and *Mahidol University* of *Ministry of University Affairs*.

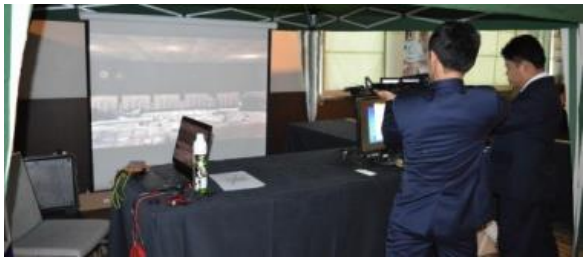

Figure 13: One-screen *VSR* simulator in technology demonstration

5.2. National Research Policy and Strategy

The *VSR* has mirrored Thailand's National research policy and strategy Volume 8, Strategy 9 that it reinforced national defense and security whereby providing the *fire-arms training simulator* that placed the users at the center of the research and development. It also integrated solutions as training scenarios (see the *Software Validation* part in *Project Validation* of Fig. 10) to solving domestic unrest such as *air base defense from ground attack* and *patrol mission and fightback* scenarios. The scenarios were an add-on feature of the *small scale architecture* or one-screen of the *VSR*.

5.3. Living up to Expectations

The author proposed the *Double Pyramid* approach that needs further numerical validation using the formulated (1) and (2). In (1), the variables planned_institute, performed_institute, planned_ project and performed_ project are easier to measure while the rest are cumbersome but achievable with focus group or questionnaire. All the variables of (2) are measurable and within the planned and achieved Publications. At the time of writing this report, the author is investigating more on the proposed approach.

5.4. Improvement of National Competitiveness

The *VSR* was successful with the improvement of national competitiveness when its extended version to the *small scale VSR* was presented at the *MilSim Asia* during 17-18 January 2017. *DTI* had gained international reputation since *DTI* researchers of this project submitted their research and development concepts and findings leading to and resulted from this project in several international conferences (Kumsap et al (2013), Chalainanont et al (2013), Kumsap et al (2014), Chieochan et al (2015), Tanvilaipong et al (2015), and Tepkhunchorn et al (2015)). Most importantly, the work by Robert et al (2016) with the use of *DTI*'s *tool* and *database* received the *Best Paper Award* from *International Defense and Homeland Security Simulation Workshop, September 26-28 2016, Cyprus*.

In addition, one of the research byproducts as fully explained in Chalainanont et al (2013) was developed under the realm of information and communication technology that was used in field survey and ground truth missions in the *VSR* project was used in the *DSI Map Extended* under the MoU between *DTI* and *DSI*. The researchers managed to build potential software from its extension to the capability as discussed by Kingkangwan et al (2015). *Computer - based Training* (see Fig. 9) and *Virtual Gun Assembly* (lower right inset of Fig. 9) were also identified by the *NRCT* as having the hardware potential and software capabilities to improve Thailand's hardware and software industry and advised to report for research grant from the *NRCT*.

6. CONCLUSIONS AND RECOMMENDATIONS

This original article shares with military simulation and training community the *VSR* project of *DTI*'s *military simulation and training Master Plan* as the case study to reflect its compliance with the explained strategies. The research and development activities were managed in order for the project's researchers to *define* the user requirements, *design* the system architecture, *develop* the system, and *deliver* the project output. It further contributed to the project management community by introducing the *Double Pyramid* approach that values Publications against Expectations. Numerical investigation on the proposed equations, however, is needed further to validate the approach and equations. Additionally, it discussed that the *VSR* had fulfilled the objectives of the *DTI Establishment* by the delivery of the systems to the users, by the creation of research partnerships through MoU, by the reinforcement of national defense and security with the training simulator, by the integration of hardware and software solutions to solving the domestic unrest, and by the improvement of Thailand's scientific and technological recognition in the international showcases.

DTI has missions, vision and core values to define its strategies that rule the objectives, roles and responsibilities entitled by the *Royal Decree of DTI's Establishment*. This article shows how the *VSR* project case study was managed to comply with the policy of the institute up to the national level. However, the *Royal Decree Article 1 Codes 7 (1)* also requires *DTI* to execute missions relevant or related to defense technology development. Research and development prototypes should be financially supported for the same actions as the research grant provide by the *NRCT* so that the potential prototype can be commercialized and put in line of production. Within the introduced *Double Pyramid* framework, the author is validating the viability of the approach and expecting is publication soon. However, it is recommended that further research on commercialization and manufacturing topics in the context of Thailand's defense technology research prototype should be carried out. Evidence from the *VSR* project conveys the message that the research and development project that is widely accepted either by national or international domains is feasible for upgrading to the commercialization and manufacturing phase. Last but not least, byproducts of the project can

be extended and enhanced as a research project by the agreement of the signed memorandum of understanding.

REFERENCES

Atkinson, R., (1999) Project management: cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria, International Journal of Project Management, Volume 17, Issue 6, pp. 337–342.

Ben Mahmoud-Jouini, S., Midler, C. and Silberzahn, P. (2016), Contributions of Design Thinking to Project Management in an Innovation Context. Project Management Journal, 47: 144–156.

Chalainanont, N., Kumsap, C., Boonprasert, P. (2013) An Android-based Interface of Mobile Network for Real-time Field Survey and Ground Truth Missions, *Proceedings of the 34th Asian Conference on Remote Sensing 2013*, pp. 4193 – 4200.

Chieochan, S., Pratoomma, P., and Kumsap, C., (2015), Distributed Virtual Environments for Military Training Applications: Trends and Challenges, Proceedings of The First Asian Conference on Defense Technology, ACDT2015, April 23 - 25, 2015, Hua Hin, Thailand, pp. 27-32.

Defense Technology Road Map 2010 - 2024, Defense Technology Institute (Public Organization), 24 p. [*In Thai*]

Haddawy, P., (2016), Manual of Virtual Shooting Range Validation for the Virtual Shooting Range project, Information and Communication Technology, Mahidol University, 23 August 2016, 57 p.

Kingkangwan, K., Chalainanont, N. and Kumsap, C., (2015), Triple-Mode Location-Aware Andrioid Portable System for Field Operations, Proceedings of The First Asian Conference on Defense Technology, ACDT2015, April 23 - 25, 2015, Hua Hin, Thailand, pp. 63-66.

Kumsap, C., Chalainanont, N., Sontayamal, T. (2013) Using High Level Architecture for an Information Exchange: A DTI's Integrated Approach of Modeling and Simulation, Proceedings of the 34th Asian Conference on Remote Sensing 2013, pp. 4278 – 4284.

Kumsap, C., Chalainanont, N., Meekhla, W., (2014), An Approach of Geo-computation for Automatic Placement of 3D Building Models, Unpaginated CD-ROM, 10th Asia GIS 2014 International Conference, Chiang Mai, Thailand, 16-17 June 2014.

Kumsap, C., Meegla, W. (2013) Basic Components of DTI's Simulation and Training, *National Defense Studies Institute Journal*, pp. 64 – 70. (In Thai)

Kumsap, c. (2017), Speaker Interview for the topic of development and application of NRCT's Economy Virtual Shooting Range. http://www.milsimasia.com/page/interview-with-gp-capt-dr-chamnan-kumsap/ [Accessed 19 February 2017].

Memorandum of Understanding between Defense Technology Institute (Public Organization) and Land Development Department for the terms and understanding between the two parties to utilize digital map and mapping data of Land Development Department on defense technology signed on 18 May 2013. [*In Thai*]

Memorandum of Understanding between Defense Technology Institute (Public Organization) and Department of Special Case Investigation for the terms and understanding between the two parties to research and develop defense technologies for special case investigation signed on 23 July 2015. [*In Thai*]

Memorandum of Understanding between Defense Technology Institute (Public Organization) and Mahidol University for the terms and understanding between the two parties to academic collaboration and research knowledge and human resources development on defense science and technologies signed on 8 October 2014. [*In Thai*]

National Research Policy and Strategy volume 8 (2012 - 2016), the National Research Council of Thailand, 90 p.

Robert, O. P., Kumsap, C. and Janpengpen, A., (2016) Modeling drug trafficking routes using potential surface analysis for the simulation of military training scenarios, Proceedings of The 6th International Defense and Homeland Security Simulation Workshop, September 26-28 2016, Cyprus, pp. 35-43.

Royal Decree of the Establishment of Defense Technology Institute (Public Organization) on 27 December 2008, 73 p. [*In Thai*]

Tanvilaipong, N., Chalainanont, N., and Kumsap, C., (2015), Database Management to Support Automatic Placement of 3D Building Models to A Simulated Scene, Proceedings of The First Asian Conference on Defense Technology, ACDT2015, April 23 - 25, 2015, Hua Hin, Thailand, pp. 172-176.

Tepkhunchorn, K., Khantong, R., and Kumsap, C., (2015), Modeling and Simulation as an approach to create Awareness of Thailand Aerospace Technology Ambition, Accepted for Publication in the 2015 International Conference on Modelling, Simulation and Applied Mathematics (MSAM2015), August 23-24, 2015, Phuket, Thailand.

AUTHOR'S BIOGRAPHY

Chamnan Kumsap used to work in the Royal Thai Air Force until the rank of Group Captain and recently worked as a project director of the Virtual Shooting Range project at *Defense Technology Institute (Public Organization)*. He received the Ph.D. degree in Remote Sensing and *GIS* in 2005. His research interests include military simulation and training, modeling and simulation, *GIS*, terrain modeling, *UAV*-based terrain modeling. His e-mail address is: chamnan.k@dti.or.th.