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Regina Borek-WOJCIECHOWSKA<sup>1</sup>, Jarosław FIGARSKI<sup>2</sup>, Wojciech POKORA<sup>3</sup>

## USE OF SIX SIGMA FOR QUALITY ASSURANCE IN THE ARMS INDUSTRY

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*The purpose of this paper is to present military applications of the quality assurance method called Six Sigma. This method is applied worldwide to manage quality. It is used by major global enterprises including those producing goods for military purposes. One of its greatest users is the Army of the United States of America as well as other national armies. Six Sigma is part of strategies used in enterprise management, in which quality is perceived as a crucial factor in improvement of competitive market advantage as well as a solution enabling confrontation with emerging threats. Functioning of an army is connected not only with activities related to military operations, but also with purchase of military equipment and other goods, repairs of the equipment, health protection, data collection, transportation, and storage. Six Sigma and solutions based on experience with the method may be applied to all of these areas.*

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### Introduction

A survey carried out among business entities of the Polish arms sector by P. Bartkowiak and J. Józwiak in the years 2013–2015 proved that 100% of those enterprises

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<sup>1</sup> Associate Professor, PhD, Eng., University of Technology and Humanities in Radom, Faculty of Economics and Legal Sciences.

<sup>2</sup> Ph.D student, MSc. Eng., University of Technology and Humanities in Radom, Faculty of Economics and Legal Sciences.

<sup>3</sup> Director, PhD, Quality Certification Center, Military University of Technology, Warsaw.

were certified for compliance with the requirements of ISO 9001 and 90% for compliance with the requirements of AQAP 2010 (see Bartkowiak, Józwiak, 2017). Thus, establishment of a quality management system has become a standard with enterprises manufacturing military goods. As the authors indicate after R. Wolniak (see Wolniak, 2014), such a situation forces enterprises to follow the path of continuous improvement, provided that they search for unique factors helping to gain competitive advantage.

Enterprises improve their quality management systems in order to achieve specific benefits present in three areas: financial, organizational (improvement of a management system), and the market (improvement of a company's standing) (see Wolniak, 2014). Publications concerning quality management emphasise the leading role of the management in achievement of quality goals. Global and local competition force business leaders to create changes and guide development as, due to their knowledge and skills, they are better prepared for any kind of changes both in an enterprise and in its environment (see Karaszewski, 2001).

Enterprises which implement the quality management standard ISO 9001 employ the term „process approach”, meaning a systematic identification of processes applied in an organization together with management of the said processes, as well as mutual connections of processes that function in the organization. Such an approach to quality management leads to a transition from the quality control stage, through the steering and quality assurance stage, to the comprehensive TQM quality management. The TQM philosophy helps organizations to achieve their goals, such as defect-free production and full satisfaction of customer needs and demands. Striving towards constant improvement of the processes, minimization of their variability, maximum possible savings on improvement of the quality of goods, may encourage management to apply the Six Sigma method (see Kaźmierczak, 2002).

## **1. Using Six Sigma in the arms industry**

To begin with, Six Sigma was used to improve quality in the manufacturing industry. The success achieved by enterprises was noticed by the education, health care and services sectors. National administration was the last sector to show interest in the potential of Six Sigma, given the entrenched bureaucracy, reluctance to change, no need to compete in the market, and facility to hide losses (see Smith, 2017).

Studies confirm that Six Sigma is the most important factor in development of major enterprises operating in the territory of the United States of America and Europe. The method is most commonly applied in the automobile and aviation industries. It may be said this is a standard among the key sub-suppliers to these sectors (see Tyszkiewicz, 2016).

Fortune 500 list of the leading enterprises covers five American companies manufacturing goods for arms purposes: Boeing (ranking 24), Lockheed Martin (ranking 26),

General Dynamics (ranking 90), Northrop Grumman (ranking 114), and Raytheon (ranking 116) (Fortune 500, 2017). The British BAE Systems is the largest enterprise of this kind beyond the US, whose arms production profits place it third in the world (see Bhushan Dhiraj, 2017). Six Sigma figures large among the quality assurance systems in all these organizations.

A segment of Boeing produces arms goods: aircrafts, missiles, and rockets. At the beginning of the 1990s, the Lean Manufacturing rules were intensely introduced there. Not until the end of the 1990s were they supplemented with Six Sigma initiatives. Six Sigma in Boeing does not have a corporate mandate, however, it is perceived as one of the most important elements for the company's competitiveness. The monthly corporate bulletin (Boeing Frontiers) publishes articles about Six Sigma and stories of successful improvements (see Marx, 2017).

Global armament concerns introduce Six Sigma in order to improve their effectiveness and reduce costs. This method has been successfully used to improve business processes by Lockheed Martin since 1990. In recent years, potential of Six Sigma has been noticed and now the method is also used for assurance of business sustainability. Application of Six Sigma helps to enhance strengths of an organization and to pursue its strategy and high level management is aware that respect and support for employees, society and environment are keys to success of a company. Six Sigma projects in Lockheed Martin are carried out in the following areas of interest:

- Operation efficiency – costs in this area have been decreased by 20% due to reduction of space occupied and thus of consumed energy and other resources;
- Use of resources – since 2010, water consumption and CO<sub>2</sub> emissions have been cut by approx. 20%. Moreover, quantities of materials landfilled have fallen by 36% and consumption of energy dropped by 12%;
- Product manufacturing – the knowledge that creation of new products leads to changes in the environment resulted in cooperation with other entities seeking alternative energy sources, methods of waste disposal and problem solving connected with the climate change;
- Contacts with suppliers – transparency is the basic parameter. Improvement of decision making processes allowed for introduction of higher standards of social and business dealings with the company's partners (see Zell, 2017).

General Dynamics offers the following ranges of goods: sea systems, fight systems, information and technology and aerospace. Lean Six Sigma methodology was to force the company to show greater flexibility in the changing market. The following factors led to the introduction of Six Sigma:

- immunizing the company to the decline in prices;
- growing pace of improvement in quality and efficiency compared to the competition in order to become the most efficient rival in the market;

- establishing a universal language and approach in the entire area of business interest of the company;
- developing the next generation of leaders;
- problem-free realization of orders giving satisfaction to the customers;
- measurable financial benefits;
- positive and deep cultural changes and engagement in constant improvement of all key business goals (see Quality Toolbox-Tools & Techniques, 2017).

Six Sigma in Northrop Grumman is one of the pillars of its quality assurance programmes (see Quality Assurance Program, 2017) applied in order to satisfy the customer. The said programmes use the best standards and practices available in the industry and aim to provide highest quality products and services. Application of Six Sigma in order to improve functioning of processes and reduce aberrations is to significantly contribute to increased effectiveness and improved quality, at the same time reducing waste. By means of statistical methods using data from descriptions, measurements and analyses, improvement and monitoring of crucial business targets becomes possible. The approach towards the improvement systematized by the DMAIC methodology gives employees extra motivation and satisfaction from their work (cf. Quality Assurance Program, 2017).

The high rank attained by Six Sigma method at Raytheon is proved by the fact that individual frameworks were created for it and it was given its own name (R6σ®). Six Sigma is a business strategy of Raytheon for the benefit of constant improvement. It considers all aspects of enterprise functioning – processes, employees, suppliers, customers, and partners. Its role is to boost efficiency, provide positive impact on the business, and satisfaction to its customers. It was introduced in 1998 as a combination of the experience of Six Sigma classic approach originating from Motorola and the Lean aspects implemented by Toyota. Consideration given to needs of the customer and implementation of the organizational culture, elimination of losses, limitation of process variability, and engagement of employees are very important in this consolidated attitude. A standard introduced to Raytheon will support achievement of goals, reduce risk and contribute to improvement of products and services, provide each employee with tools and resources necessary to create value in this field. Any information obtained at every R6σ stage assists the team with changing their way of thinking, leads to improvement of the efficiency and achievement of considerable effects. Engineering solutions and R6σ in a company mutually inform and supplement each other. Engineering personnel is obliged to reduce costs, maintain efficiency, improve results, and limit the variables influencing stability of the process. In this area, R6σ provides IT, analytical and project solutions which make products and processes profitable. Engagement in the participation in the R6σ projects supports careers and personal development of employees (see Technology Today, 2017). Individuals with skills gained during realization of the projects, with knowledge of the R6σ concept and additionally leadership and

management skills, experience, and absence of fears related to introduction of changes are potential candidates for managerial positions. Thanks to such an attitude, leadership of a company is strong and experienced in application of constant improvement tools as well as engaged in continuous improvement processes.

The philosophy of BAE Systems concentrates on achievement of goals by way of grounding the organizational culture not in what we are doing but how we are doing it. Such an approach enforces the highest standards in every aspect of the business. The strategy of continuous improvement was realised owing to introduction of Six Sigma, among other methods. Like in the other companies, the basic aim in BAE Systems was introduction of the methodology to solve problems (identification and elimination of defects, minimization of production process variability) allowing for improvement of processes in the strategic areas of the organization, thus in consequence, improvement of quality. Six Sigma uses statistical methods thanks to which people building its infrastructure in an organization (Champions, Black Belts, Green Belts, Yellow Belts) are able to improve processes, solve business problems, introduce innovations, and educate other employees. Each project carried out at BAE Systems is composed of a specified sequence of steps and includes quantitatively specified goals, for instance:

- shorter duration of the process cycle;
- reduction of pollution;
- cut costs;
- reduction of faulty products;
- improvement of reliability;
- elimination of activities which do not increase value;
- enhancement of customer satisfaction;
- increase of profits.

The Lean Six Sigma culture at BAE Systems is a combination of both the Lean manufacturing processes and Six Sigma methodology, implemented in 1997 as the Lean Sigma in order to protect the company's share in the air market. The implementation of the Lean Sigma programme resulted in improved efficiency, time of performance, savings and reliability and is deemed the activity which has helped BAE Systems keep its position in the global forefront of armament goods manufacturers. Moreover, a Sigma Leadership programme was established as part of the programme that constitutes a career path for individuals with a leadership potential and the ability to gain knowledge from different areas of the business (cf. White, 2017).

The above listed examples create the image of Six Sigma in the arms industry as a methodology established and being continuously improved in the international and multicultural environment combining a number of sectors and disciplines. It is another aspect confirming the strength and potential of Six Sigma.

## **2. Use of Lean Six Sigma in the Army of the United States**

The US Army is considered to be one of the most effective organizations in the world. It is not an enterprise, however, it has a budget comparable to the top ten Fortune 500 companies. Its objective is to fight and win wars, yet it is aware that it has to introduce innovative solutions and manage the tax payers' money properly. For this reason, introduction and maintenance of management good practices is necessary, so that every dollar spent could serve improvement of combative dexterity. The Army often focuses on spending of the budget irrespective of results and without exact understanding of real costs of the spending processes. Such an attitude leads to bad business practices; the effectiveness and efficiency are not analysed. Thus, identification and management of process costs seem necessary (see Army Directive 2016-16). One of the methods supporting these activities is Lean Six Sigma.

Lean Six Sigma was for the first time introduced to the Army of the United States in 2006. Billions of dollars have been saved as a result. One of the activities designed to increase effectiveness was the expenditure of 2.8 million dollars on purchase of software used for statistical data analysis from a leading global supplier. The aim of this purchase is to help assure self-sufficiency of Lean Six Sigma techniques, generate greater profits, cut losses, and increase benefits in the future. The West Point Military Academy is an organization where a number of Lean Six Sigma trainings was provided.

The U.S. Army units that are most effective at introduction of process improvement techniques are annually honoured with Process Improvement Deployment Excellence Awards. The following units received awards in the last edition (total savings to the amount of 74.9 million dollars):

- The Office of the Assistant Secretary of the Army for Financial Management and Comptroller;
- The U.S. Army Medical Command;
- The 21<sup>st</sup> Theater Sustainment Command, U.S. Army Europe (see Lopresti, U.S. Army..., 2017).

It is worth emphasizing that thanks to participation in the Six Sigma certification process, the military personnel have a chance to develop skills necessary to apply for the most attractive jobs not only in the army but also after completion of their service. Holders of a safety certificate together with the Six Sigma certificate are very attractive work candidates for the private sector.

Six Sigma methodology applied in the army was adjusted to its specific nature and brought significant benefits for military units, the American Defence Department, and private contractors. The achievements in the field of process improvement of cost reduction gained recognition in the form of Lean Six Sigma Excellence Awards. In the last edition (see May 2017), 13 Lean programmes have been honoured. The programmes recognised allowed the U.S. Army to save millions of dollars. Detailed analysis and im-

provement of processes aiming to eliminate losses are perceived as ways to strengthen the power of the U.S. Army (cf. Lopresti, *Six Sigma...*, 2017). It is stressed that the improvements not only eliminate the waste of time and thus extend the training period of soldiers, but also make life simpler. Management of such factors as purchasing, logistics, health care, and human resources may be operated only with the use of modern business strategies which function in the private sector. The projects which contributed to success of the awarded units included:

- shorter training cycles;
- reduced time spent on repairs of military equipment;
- savings on purchases of products and services for the army;
- less time spent on office activities;
- less time spent on data processing;
- health protection (shorter waiting times for examinations and surgeries);
- improvements for soldiers and their families in case of a change of unit assignment.

What is important, the solutions introduced to the U.S. Army, which contribute to measurable savings, are also implemented in other units. It is especially significant from the point of view of Six Sigma's effectiveness.

A armies in different parts of the world pay close attention to improvement of processes by means of Six Sigma. In 2014, the South Korean Ministry of Defence saved 92 billion Korean won (approx. 290 million Polish zloty) thanks to introduction of 107 Lean Six Sigma projects. The following projects were distinguished:

- evacuation sideslip for Navy vessels (to be also applied to sinking and burning civil vessels),
- solution preventing engine problems in Russian T-103 training airplanes,
- improved effectiveness of military resources management,
- improved efficiency of artillery exercises,
- optimization of resource management and quality control during maintenance of the „White Shark” torpedo (see Chung, 2017).

Mikel Harry (called the „father” of Six Sigma), who created Six Sigma together with Bill Smith of Motorola, conducted consultations with the federal government of the United States on possible use of Six Sigma to improve the volume of intelligence information gathered by the U.S. in the fight against terrorism (cf. Smith, 2017).

## Conclusion

Introduction of Six Sigma means introduction of a number of changes to an organization. This is not a method that could be top-down implemented by way of management, regulation or any other instruction. In order to assure its success, constant support of the highest level management must be provided.



The methodology of Six Sigma is full of solutions which must be implicitly observed. Employees with conservative attitudes will probably see in Six Sigma a threat to their status quo, whereas those open to changes will approach the idea enthusiastically and will have the possibility to affect their working environment based on any available methods and tools of quality assurance (participation in Six Sigma projects also helps in personal development of employees).

Positive effects of introduction of Six Sigma in such companies as: Boeing, Lockheed Martin, General Dynamics, Northrop Grumman, Raytheon, BAE Systems or the Army of the United States of America invite special attention to the possibility of using Six Sigma to improve quality in the Polish arms industry. The introduction of Six Sigma to national arms sector may result in improvement of the business approach as the authors of this method were driven by the idea of increasing profitability of an enterprise. Limitation of the process variability owing to Six Sigma results in financial savings and in reduction of funds allocated to quality assurance. The implementation does not have to encompass the entire organization. It may be carried out for particular processes, it may concern smaller organizational units, whereas success of some projects may positively affect other units.

## References

- Army Directive 2016-16 (Changing Management Behavior: Every Dollar Counts)*, <https://www.army.mil/e2/c/downloads/441522.pdf>, accessed on 14.10.2017.
- Bartkowiak, P., Józwiak, J. (2017). *Determinanty doskonalenia systemu zarządzania jakością w przedsiębiorstwach branży zbrojeniowej w Polsce*, *Problemy Jakości*, 8, pp. 2–9.
- Bhushan Dhiraj, A. *The Top 25 Largest Defense Companies In The World*, 2015, <http://ceoworld.biz/2016/02/17/the-top-25-largest-defense-companies-in-the-world-2015/>, accessed on 14.11.2017.
- Chung, S. *Korean Navy Wins Gold Prize for Developing Ingenious Evacuation Slide*, <http://koreabizwire.com/korean-navy-wins-gold-prize-for-developing-ingenious-evacuation-slide/27010>, accessed on 14.10.2017.
- Fortune 500, <http://fortune.com/fortune500/list/filtered?sector=Aerospace%20%26%20Defense&industry=Aerospace%20and%20Defense&sortBy=rankchange>, accessed on 14.10.2017.
- Karaszewski, R. (2001). *Tylko dla liderów Sześć Sigma*, *Problemy Jakości*, 6, pp. 9.
- Każmierczak, M. (2002). *Sześć Sigma – niezbędne elementy doskonalenia procesów i budowy przewagi na rynku*, *Problemy Jakości*, 7, pp. 30.
- Lopresti J., *Six Sigma Certification Benefits Military Personnel During and After Service*, <http://www.sixsigmadaily.com/six-sigma-certification-military-benefits/>, accessed on 14.10.2017.
- Lopresti J., *U.S. Army Prioritizes Lean Six Sigma Training*, <http://www.sixsigmadaily.com/us-army-lean-six-sigma-training/>, accessed on 14.10.2017.



- Marx, M. *Boeing*, <https://www.isixsigma.com/industries/aerospace-and-defense/boeing/>, accessed on 14.10.2017.
- Quality Assurance Program*, <http://www.northropgrumman.com/AboutUs/Contracts/SeaPort-e/Pages/QualityAssurance.aspx>, accessed on 14.10.2017.
- Quality Toolbox – Tools & Techniques*, [http://www.gdls.com/suppliers/quality/quality\\_toolbox.pdf](http://www.gdls.com/suppliers/quality/quality_toolbox.pdf), accessed on 14.10.2017.
- Smith, L. *Six Sigma goes to Washington. Public agencies from the Navy to city governments, improve quality*, [https://www.qualitydigest.com/may05/articles/01\\_article.shtml](https://www.qualitydigest.com/may05/articles/01_article.shtml), accessed on 14.10.2017.
- Technology Today, Raytheon Six Sigma™ Promotes Success*, [https://www.raytheon.com/news/technology\\_today/archive/2012\\_i2.pdf](https://www.raytheon.com/news/technology_today/archive/2012_i2.pdf), accessed on 14.10.2017.
- Tyszkiewicz, A.M. (2016). *Efektywna Six Sigma? O wpływie Six Sigma na kondycję finansową firmy*, rozpisani.pl, pp. 88.
- White, G. *BAE Systems achieves excellence with lean sigma*, <http://www.manufacturing-global.com/lean-manufacturing/bae-systems-achieves-excellence-lean-sigma>, accessed on 14.10.2017.
- Wolniak, R. (2014). *Korzyści doskonalenia systemów zarządzania jakością opartych o wymagania normy ISO 9001:2008*, *Problemy Jakości*, 3, pp. 20.
- Zell, S. *Six Sigma Guides Lockheed Martin Toward Corporate Sustainability Goals*, <http://www.sixsigmadaily.com/six-sigma-guides-lockheed-martin-sustainability-goals/>, accessed on 14.10.2017.