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Defense Capabilities Development and Defense Industry, U.S. Case Study

Védelmi képességfejlesztés és védelmi ipar, USA esettanulmány

New product development is a very complex process independent of the domain, and defense industry is not an exception, being an especially challenging process that involves interactions between industrial suppliers of goods and services with multiple government offices often trying to balance competing objectives. The big dilemma is: How governments acquire the equipment, goods, and services needed for their armed forces at a reasonable price, appropriate quality, and with a reasonable time frame? Complex weapon systems are developed by the Ministry of Defense (MoD) through the defense acquisition system, which must provide more affordable systems as a matter of national security. Yet the defense acquisition system is in a perpetual state of reform, the fact is there is no evidence of improved acquisition outcomes. In this research, U.S. MoD defense acquisition system will be analyzed and the reforms that had to be made to improve the current acquisition outcomes.

Keywords: acquisition process, capabilities development, systems engineering, new product development, defense industry

Az új eszközök fejlesztése, területtől függetlenül mindig nagyon komplex folyamatot jelent, természetesen a védelmi ipar sem kivétel ez alól, hiszen ez egy olyan kihívásokkal teli ágazat, amely az ipari termékek és szolgáltatások beszállítói és a kormányhivatalok közötti kapcsolatot foglalja magában, és gyakran az egymással versengő célkitűzések kiegyenlítésére van szükség. A nagy kérdés a következő: az egyes országok kormányai hogyan vásárolják meg a fegyveres erők számára szükséges felszereléseket, eszközöket és szolgáltatásokat elfogadható áron, megfelelő minőségben és észszerű határidőn belül? A bonyolult fegyverrendszereket a Honvédelmi

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Minisztérium a védelmi beszerzési rendszerén keresztül dolgozza ki, amely nemzetbiztonsági szempontból megfizethetőbb rendszert kell, hogy biztosítson. Azonban a védelmi beszerzési rendszer jelenleg úgynevezett reformállapotban van, hiszen a javuló eredmények még váratnak magukra. Ebben a tanulmányban az Amerikai Védelmi Minisztérium beszerzési rendszerét elemezzük és azokat a megvalósításra váró reformokat, amelyek a jelenlegi beszerzési folyamat eredményeinek a javításához elengedhetetlenek.

Kulcsszavak: **beszerzési folyamat, képességek fejlesztése, rendszerfejlesztés, új eszközök fejlesztése, védelmi ipar**

Introduction

Decisions associated with how to balance the competing objectives of delivering new military equipment at a reasonable price, with the appropriate quality, and with a reasonable time frame are normally taken under an environment defined by high stakes, high accountability, and high uncertainty. New product development at a high level at the Ministry of Defense (MoD) is achieved through a complex defense acquisition system, with also many opportunities for improvement. Despite its limitations, the defense acquisition system is proved to be an effective way to produce weapons that have performed well in battle [1].

Military planning is loaded with uncertainties, which demands an in-depth analysis of the scenarios where our troops will operate and the threats to which they will be exposed and, of course, imaginative solutions (scenarios). Military planning should not focus only on determining the means necessary for a specific type of conflict or mission, but it should be much more general and aimed at obtaining capabilities that allow covering a broad spectrum from them. Now, it must take into consideration that to obtain the most accurate results, the most likely scenarios will have to be included and the most demanding operational environments. In military terms, capabilities are "the set of factors (systems of weapons, infrastructure, personnel and logistical support) settled on the basis of doctrinal principles and procedures, that they seek to achieve a certain military effect at a strategic, operational or tactical level to fulfil the assigned missions" [2]. That is to say, a military capability is not only a weapon or a weapon system, but also a set of factors, more or less critical, but all equally important for achieving the desired effect.

New military equipment or more complex weapon system development are developed by the MoD through the defense acquisition system, which must provide more affordable systems as a matter of national security. The defense acquisition system is perceived to be in a perpetual state of reform in many countries without any evidence of improved acquisition outcomes, but indeed the reality regarding product development process all around the world is not different from the defense situation.

Global Performance Assessment for New Product Developments

Many new products' development fails; the Product Development and Management Association (PDMA[2]) led an international comparative research and multi-industry performance analysis in 2012 and determined that approximately 39% of all new developments had failed to reach the market with a minimum level of failure, even more, the failure rates grew by over 54% in the case when the development of new products required high levels of innovation [3].

According to the studies carried out by the PDMA dating from 1990 and shown in Table 1, the failure rate for the development of new products would be around 40%, which is consistent with the empirical studies conducted by [4] that analyses studies and reports since 1977 to 2010 and that estimate a failure rate for new products of 40%, thus demonstrating that the failure rate has been constant over time.

Table 1.
History and results of comparative performance assessment study CPAS [Made by the author.]

N° Study	Year	Sample (Bussiness Units)	Fail Rate (%)
1st Study	1990	189	42
2nd Study	1995	383	41
3rd Study	2004	416	41
4th Study	2012	453	39

As can be seen in Figure 1 and analyzing data report from PDMA 2012, only 44% of the new products with moderate innovation met the development schedule on time and 49% of them met the initial budget restrictions. The situation is not better in relation with new products with radical innovation, only 29% of the new products with a high level of innovation met development on time and only 32% of them met the initial budget restrictions. These poor records of new product achievements are shared all across the world without any distinction of industry, revealing that product development tasks are highly difficult.

[2] PDMA – U.S. organization created in 1976 that focuses on the unique set of integrated activities involved in the full lifecycle of product development and management, including innovation.

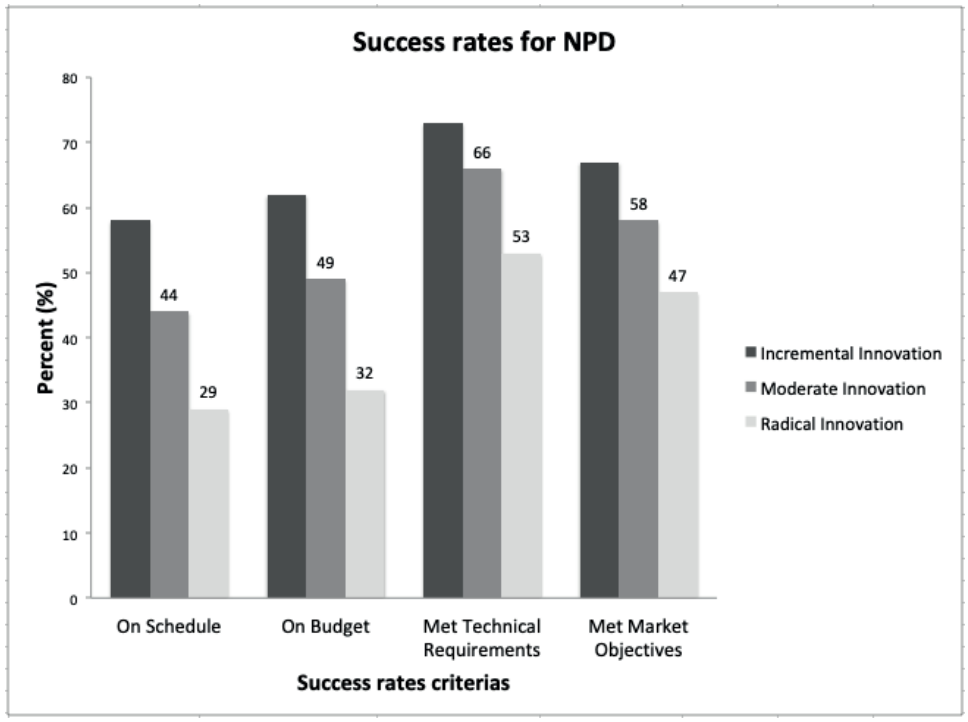


Figure 1.
Success rates for new product developments with different levels of innovation [Made by the author.]

U.S. Defense Performance Assessment for New Product Developments

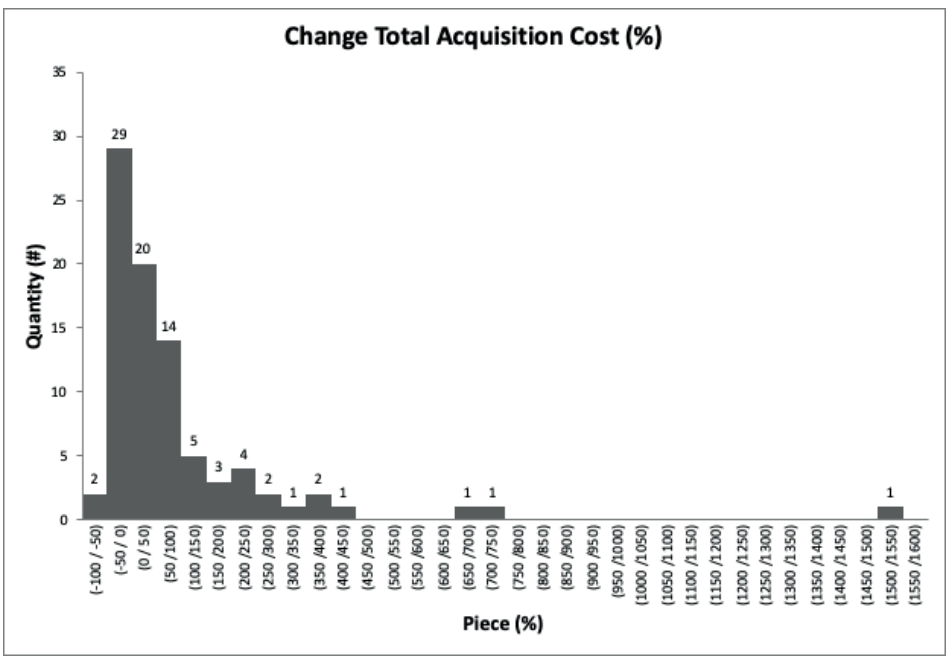
The performance of the defense acquisition has been widely discussed at many points in U.S. history. Recent years are no exception, as exemplified by the U.S. Government Accountability Office's Report (GAO[3]) and the U.S. DoD's[4] *Performance of the Defense Acquisition System Annual Report,* both listing the system for major weapon buying as "high risk" for nearly a quarter of a century. Some U.S. congressmen had pointed to the enormous total cost growth since the start of each program in the portfolio, which can mean going back to the 1990s. Under Secretary Kendall annual metrics were preferred, which show improvement in relation with previous periods.

[3] GAO – Independent, nonpartisan agency that works for Congress. GAO examines how taxpayer dollars are spent and provides Congress and federal agencies with objective, reliable information to help the government save money and work more efficiently.

[4] DoD – The Department of Defense (DoD, USDOD, or DOD) is an executive branch department of the federal government charged with coordinating and supervising all agencies and functions of the government concerned directly with national security and the United States Armed Forces.

Recent studies by other researchers, presented at CSIS[5] and the Naval Postgraduate School's Defense Acquisition Research forum [5], have particularly illuminated two metrics: cost and schedule growth.

For a performance metric of new product development within the U.S. DoD, the data contained in Table 13 of Appendix IV within the U.S. Government Accountability Office's Report to Congressional Committees (GAO-18-360SP) entitled *Weapon Systems Annual Assessment* [6] is considered. An analysis of these data reveals that of 86 programs in the portfolio of U.S. DoD's major weapon acquisition programs 2017, only about 37% of these are in a condition equal to or less than the first full estimate of total acquisition cost. This seems to be on par with the global performance records of new products that observe a medium to a high level of innovation, presented in Figure 1.



Count	Min	Max	Bin Width	# Bins	Mean	Median
86	–89	1.566	50	34	90.44	7.40

Figure 2.

Frequency histogram percent change in total acquisition costs from first full estimates
[Made by the author.]

[5] CSIS – U.S. Center for strategic and international studies. Established in Washington, D.C., CSIS is a bipartisan, nonprofit policy research organisation dedicated to providing strategic insights and policy solutions to help decision-makers chart a course toward a better world.

To get a complete state of the results obtained in the development of new products in relation to costs, data must be evaluated beyond a simple one measure of the pass–fail test. Figure 2 shows the cost distribution of 86 programs as a histogram with the associated descriptive statistics. It should be noted that although a large number of programs are effectively in or under the estimated budget line (65 programs were under 100% of the budget in relation with the first full estimate), the total cost growth for those programs that failed may be very large, with at least seven projects that failed their target costs, compared to which they amounted nearly 300% or even more. Additionally, Table 2 shows the 2017 portfolio aggregate changes in research and development (R&D), and total acquisition costs, as well as average delays in delivering operational capability since the programs' first full estimates.

Table 2.

2017 portfolio aggregate changes in R&D, total acquisition costs, as well as average delays in delivering operational capability, since the programs' first full estimates [Made by the author.]

Fiscal year 2018 - Dollars	
	Since first full estimate (baseline to December 2016)
Change in total research and development cost	$ 103.1 billion 48.9%
Change in total procurement cost	$ 430.8 billion 47.9%
Change in total other acquisition costs	$ 2.9 billion 26%
Change in total acquisition costs	$ 536.8 billion 47.9%
Average delay in delivering initial capabilities	$ 27.4 months 37.7%

According to U.S. DoD's *Performance of the Defense Acquisition System 2016 Annual Report* [7], nearly 22 of the largest defense procurement programs have been cancelled between 1997 and 2015 before reaching the stage of production of significant quantities. Although it is not reasonable or expected that all research and development (R&D) projects reach the manufacturing stage, a defense procurement process with a high level of efficiency should be able to identify those projects destined to fail before using higher resources.

In order to have an insight into the impact on the costs of those cancelled programs, Table 3 provides the sunk costs of five cancelled development projects. This information was obtained from GAO-14-77 [8] and it can be seen that it is not uncommon for the U.S. MoD to spend several billions of dollars on development programs in pre-completion stages. The opportunity cost associated with sunk-cost products of possible cancellations is that these funds could be used elsewhere in the portfolio of development programs and thus increase the rate at which superior capacities are finally delivered to the armed forces and the end-user.

Table 3.

2017 portfolio aggregate changes in R&D, total acquisition costs, as well as average delays in delivering operational capability, since the programs' first full estimates [Made by the author.]

Program	Service	Centract Termination	Sunk Costs
Aerial Common Sensor	Army lead, Navy participation	2006	$186 million
Comanche Helicopter	Army	2004	$5.9 billion
Future Combat System	Army	First partial termination in 2009, final termination in 2011	Estimated $20 billion
Transformational Satellite Communications System	Air Force	2009	Estimated $2.9 billion
VH-71 Presidential Helicopter	Navy	2009	$3.3 billion

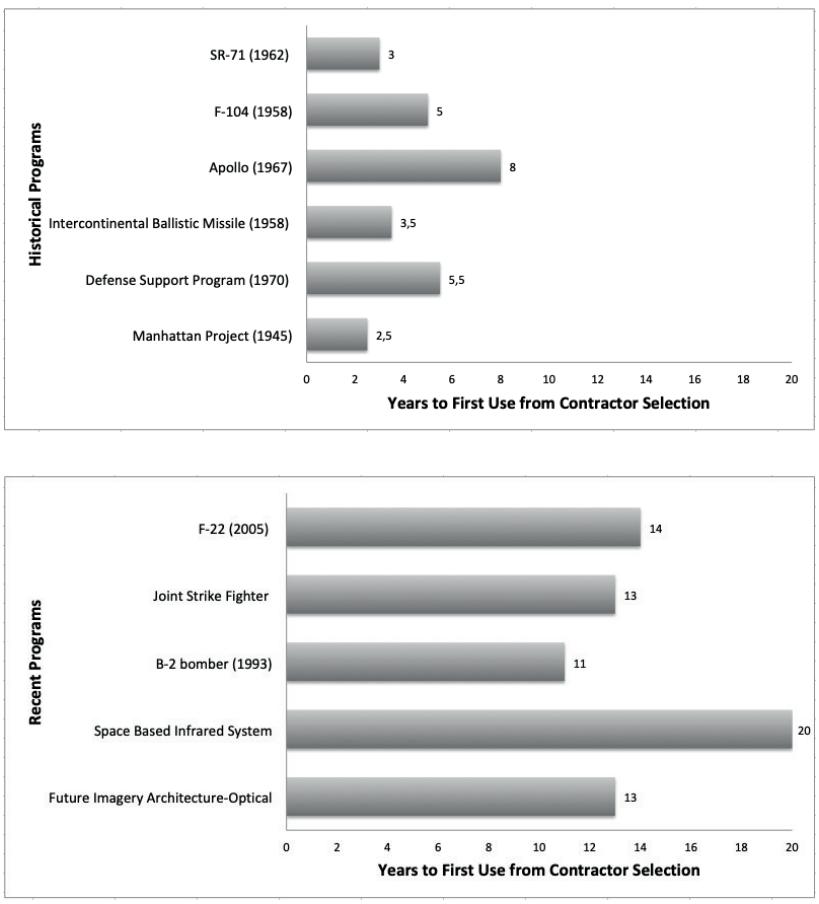


Figure 3.

Development duration of historical and recent programs [Made by the author.]

Unwanted trends in defense procurement are not only limited to the issue of costs. A recent report from the National Research Council (NRC[6]) called *Pre-Milestone A and Early-Phase Systems Engineering: A Retrospective Review and Benefits for Future Air Force Systems Acquisition* [9], highlights that in an era where product development of commercial technologies has been reduced considerably, the development time of much of the major weapons systems has increased dramatically. Figure 3 shows the duration time of historical and more recent development programs, whose data was obtained from the NRC report 2008, from which it can be concluded that the development times required for the most recent programs double or even triple the development times of historical programs.

U.S. MoD Defense Acquisition Process and Recent Reforms

The Defense Acquisition System has its foundation in the country's policy and public law. The development, acquisition, and operation of military systems are governed by a multitude of public laws, formal MoD directives, instructions and manuals, numerous Service and Component regulations, and many inter-service and international agreements. Managing the development and fielding of military systems requires three basic activities: technical management, business management, and contract management. In the U.S., systems engineering management is one of the main pillars and has to deal with the technical management component of MoD acquisition management of DAU[7] (2000) [10]. Systems Engineering Management bridges these processes and must resolve the dichotomy of event-driven needs, event-driven technology development, and the calendar-driven budget throughout its whole life cycle.

In the U.S., the Defense Acquisition System is regulated by DoD instruction (DoDI) 5000.02 *Operation of Defense Acquisition System* dated August 10, 2017. This regulation provides policies and principles that govern the defense procurement system and forms the basis for all U.S. DoD programs that include weapon systems, services and automated information systems (AIS), and also establishes a management framework for interpreting the user requirements and technological opportunities in stable, affordable and well-managed procurement programs. It also identifies the reports, regulations and other information requirements for each milestone and point of decision.

The U.S. DoD 5000 document series were revised in 2000 to make the process more flexible, enabling the delivery of advanced technology more rapidly and at reduced total ownership cost. The new process encourages multiple entry points, depending on the maturity of the fundamental technologies involved, and the use of evolutionary methods to define and develop systems. This encourages a tailored approach to acquisition and engineering management, but it does not alter the basic

[6] NRC – Organised by the U.S. National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government.

[7] DAU – Defense Acquisition University (DAU) is a corporate university of the United States Department of Defense offering "acquisition, technology, and logistics" (AT&L) training to military and federal civilian staff and federal contractors.

logic of the underlying systems engineering process. Later on, 2015 brought one of the major changes in the revised acquisition system with an increased emphasis on systems engineering trade-offs made between capability requirements and life-cycle costs early in the acquisition process in order to ensure that realistic program baselines are established in such a way that associated life-cycle costs of a contemplated system are affordable within future budgets.

The changes from the previous version of DoDI 5000.02 2013 to DoDI 5000.02 2015 [11], [12] are significant. DoDI 5000.02 2015 document sets "affordability" as one of the central themes and cites the early application of systems engineering assessments and trade-off analyses used together with a solid analysis of alternatives (AoA) as the model for reaching the desired outcomes. Concepts as "affordability", "systems engineering", "trade-off analyses" and "analysis of alternatives (AoA)" have been strongly incorporated since the revision of DoDI 5000.02 2015. In relation with "affordability", the revised defense acquisition system requires that meaningful trade-offs between capability requirements and lifecycle costs be explored early and often in order to ensure that realistic program baselines are established in such a way that associated lifecycle costs will likely fit within future budgets; the new instruction signals the increased emphasis on the AoA by dedicating an entire enclosure to the topic (Enclosure 9 DoDI 5000.02 January 2015). Finally, trade-off analysis being part of the system engineering analysis has been added to the systems engineering enclosure of DoDI 5000.02 January 2015. Table 4 shows the topics added to the Systems Engineering Enclosure of DoDI 5000.02 January 2015 considering trade-off analysis a part of the system engineering process.

Topic	DEC 2008 DoDI 5000.02	JAN 2015 DoDI 5000.02
Development Planning	Not available	Included
Systems Engineering Trade-off Analyses	Not available	Included
Technical Risk and Opportunity Management	Not available	Included
Technical Performance Measures and Metrics	Not available	Included
Modelling and Simulation	Not available	Included
Manufacturing and Producibility	Not available	Included
Software	Not available	Included
Reliability and Maintainability	Not available	Included
Program Protection	Not available	Included
Insensitive Munitions	Not available	Included
Program Support Assessments	Not available	Included

Table 4.

Topics added within the systems engineering enclosure of JAN 2015 DoDI 5000.02 [Made by the author.]

Conclusions

In this research, the defense industry dilemma was introduced concerning how to deliver new military equipment at a reasonable price, with appropriate quality, and

with a reasonable time frame under a constantly changing environment with high levels of uncertainty. New product development performance was evaluated with international studies not only for the global market but the military industry as well concluding that both shares similar performance under development with medium or high levels of innovation.

The U.S. official reports were analysed in order to visualise the performance of new weapons development programs inside U.S. DoD and how cost and time is still a big issue with the total cost of program portfolio growing by 48% in relation with the first full estimate baseline and with an average delay in delivering initial capabilities in nearly 38% of the programs. Additionally, in relation to the duration of historical and recent U.S. DoD programs, it could be concluded that recent programs in comparison with some historical programs have double or even triple development time.

Finally, we could appreciate the recent reforms made by the U.S. MoD in relation with U.S. DoD 5000 Instructions documents in order to improve the outcomes and performance of current programs, reinforcing and adding "affordability", "systems engineering", "trade-off analysis" and "analysis of alternatives (AOA)" activities and directives as a new enclosure, further strengthening its development process of new weapons systems in its main areas of technical management of development engineering, such as systems engineering, the use of analysis of alternatives (AoA) as a tool and trade-off analysis in earlier stages and in a greater number of milestones, as a way to strengthen the outputs of the new defense programs in relation to costs and time frames, given the changing prioratisation of operational requirements due to the fluctuating changes in the threat.

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