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The characteristics of successful military IT projects: a cross-country empirical study

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Abstract:
In the armed forces, successful digitalization is crucial to ensure effective operations. Much of the existing literature on project factors during the planning and execution phases of public IT projects do not focus specifically on military sector projects. Therefore, the paper aims to provide empirical insights into the characteristics of successful military IT projects. Data from such projects in NATO countries and agencies were collected through interviews and project documents. The findings relating to the main variable of interest, “delivery of client benefit,” supported previous findings on IT project performance. Medium-sized projects performed better than small and large projects, and the agile development method delivered more client benefit than traditional methods. Client involvement apparently had a positive effect on project success. Clearly specified objectives had a statistically significant effect on project success in terms of clients’ benefits. The paper contributes to the gap in research on military IT projects and broadens the project management literature’s focus on time and cost to include delivery of client benefit as a success variable. The use of cross-country data provided unique insights for academics and practitioners regarding which project characteristics affect the successful development and adoption of new software by the armed forces.

Keywords:
IT projects; project success; client satisfaction; agile development; software development; armed forces; military sector.

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1. Introduction

As in the private sector, countries' armed forces are increasingly dependent on successful investments in Information Technology (IT) products and services to ensure operational efficiency. At the same time, it is well documented that software development projects face challenges and sometimes even total failure [1],[2]. Due to the increasing dominance of software in military systems, the Defense Innovation Board in the US has stated that its ability to adapt and respond to threats is now determined by its capacity to develop rapidly and deploy effective software [3]. In this paper, we aim to contribute to the empirical body of knowledge regarding the characteristics of successful military IT projects.

In order to study success in military IT projects, we need to look beyond just measurements of schedule and budget and include delivery of client benefit/customer satisfaction as a key success parameter. This view of project success aligns with the works of Pinto and Slevin [4],[5], Pinto and Prescott [6], and Ward et al. [7]. A more recent example of client benefit included as a measure of project success can be found in the study by Mohagheghi and Jørgensen [8, p. 753], where the authors define a successful project as follows: "A project that is assessed by its project owners and users as having delivered the expected client benefits or more, and where none of the respondents report large or very large problems on the other success dimensions (time control, budget control, quality, and delivered functionality)."

This paper focuses on success in military IT projects measured by three variables: time, cost, and delivery of client benefit. Different explanations of what is behind IT project success have been reported in the literature. Prior to project start, one key decision that has been documented to affect success in IT projects is the choice of software development method. Examples are the empirical study of IT projects in Norway by Jørgensen [9], where the application of agile development practices was connected to increased rates of success. It has been shown that during project execution phase, a set of critical success factors (CSFs) affect project success [4]. Many of the studies of CSFs in IT projects have focused on IT projects in the commercial sector [8],[10],[11]. Of the few studies that have focused on military IT projects in particular, a natural starting point is the work by Tishler et al. [12]. Several studies highlight human factors as important CSFs to achieve IT project success [8],[13]-[15]. From the similarities between commercial and military CSFs within the category of human factors found during our literature review, we identified the following variables of interest to our study: *requirements*, *objectives*, *expertise*, and *involvement*.

Finally, project size and type of contract are characteristics that can contribute to IT project success [8],[9]. Furthermore, together with other variables, size in the form of monetary investment can be seen as a proxy for projects' complexity [16]. Access to skilled personnel and differences in priority are other factors that arise from differences in project size and can affect project success [8]. Regarding type of contract, the choice often lies between variants of fixed-price contracts on the one hand and per hour or time and materials (TM) contracts on the other hand, hence choosing the appropriate contract can affect the success of the IT project [9].

The research gap and the study

The project management literature is vast. Much of the literature on project factors during the planning and execution phase of IT projects focuses on either civilian IT projects or public IT projects, but not specifically on the public IT projects that are in the military sector. Military IT projects differs from other IT projects in that, for example, their deliveries function on an operational platform and/or they enable communication and interaction across different levels of classification during training and combat. Furthermore, in the project management literature, project success is defined in many ways. We follow the works of Pinto and Slevin [4] and Ward et al. [7] regarding budget control, schedule control, and client benefit as the matters of interest. One decision prior to project initiation that the literature identifies as potentially correlated with project success concerns the development method [9],[14]. The military sector has been slow to adopt methods that are well established in the commercial sector, such as agile [3], and this in turn has resulted in a lack of empirical examination. In this paper, we aim to help to fill that gap. With regard to the project execution phase, few studies have analyzed the relationship of CSFs to project success in military IT projects. Over 20 years has passed since the military sector's CSFs have been comprehensibly studied in IT projects [17]. Therefore, the aim of our study, presented in this paper, aimed to investigate the human factors identified as most important in the CSF literature, namely *requirements*, *objectives*, *expertise*, and *involvement* [13],[17]. Lastly, project size and contract type have been identified in the literature as key variables that potentially relate to project success, For this reason, we included them in our study.

A further aim of this paper is to contribute more knowledge about what contributes to success in military IT projects. Accordingly, the following overall question guides our analysis: What are the characteristics of successful military IT projects? For the purpose of our analysis, we define three more specific research questions that arise from the identified shortcomings in the literature on military IT projects:

RQ1: How does the choice of software development method contribute to success in military IT projects?

RQ2: How do the critical success factors *requirements*, *objectives*, *expertise*, and *involvement* contribute to success in military IT projects?

RQ3: How do project size and choice of contract type contribute to success in military IT projects?

To answer these research questions, we draw on original first-hand empirical data relating to project characteristics and success from IT project managers within NATO countries and other entities. The projects not only differed in their country of origin, but also in their size, time of completion, and type of acquisition. In Section 2 we present our review of the literature on the relevant parameters that contribute to project success. The review forms the basis for our three research questions and framework of analysis. A description of data and method is then presented in Section 3. Thereafter, the results and discussion are presented in Section 4. Section 5 contains the conclusions drawn from the study, as well as the study's limitations.

2. Literature review

2.1 IT project success

As stated by Atkinson [18], there are many dimensions of success in projects. A wide divergence of opinion in the field of project management can be found in the literature review by Prakash Prabhakar [19]. For IT projects, the traditional starting points for measuring project success are aligned with the three most common criteria in project management: budget control, schedule control, and delivery of the required functionality [13]. Measuring success in military IT projects can be done by using these three criteria. However, with regard to the delivery of technical functionality, one can include whether actual client benefit is delivered from the project. This view aligns with that of Ward et al. [7], who claim that technical functionality alone does not deliver benefit. Rather, it is seen more as an enabler to create benefit in changing how the client works, as argued by Garousi et al. [10, p. 215]. The reported rate of failed and successful IT projects varies greatly in the literature. Emam and Koru found in their review that the cancellation rate varied between studies, and that most were below 20% [20]. When IT projects that had to some extent failed to deliver on the success parameters were also taken into account, 48–55% of the delivered projects were considered successful. In a study of nearly 800,000 IT projects, Jørgensen found that 14% were either cancelled or had a client rating of "poor" or worse [21]. When it comes to success in military IT projects in particular, fewer cases are reported in the empirical literature. One such case can be found in the study of ca. 250 large defense software projects implemented between 1995 and 2004, as Jones found that only 25 were successful in the sense that they were on schedule, on budget, and met quality objectives [22]. The majority of the studied defense software projects (ca. 175) experienced substantial delays and budget overruns or were terminated without completion. Elsewhere, studies based on empirical data from defense software projects have focused on themes such as the estimation of effort in software testing [11] and conceptual contributions to why software projects fail [23].

2.2 Software development method

One key decision project managers make prior to project initiation is which development method to employ. Options range from traditional methods, such as waterfall or spiral development, to newer agile methods. The private sector has widely adopted agile methods in IT projects since the online publication of the Manifesto for Agile Software

Development (shortform: the Agile Manifesto) in 2001 [24],[25]. However, the public sector in general and militaries in NATO countries in particular have only recently begun to embrace agile methods.

The cost and schedule benefits of agile method over traditional development methods is hotly debated. For example, Mazazinius and Feldt [26] found the success in terms of cost and time was not significantly different between agile and non-agile companies. By contrast, Serrador and Pinto [14] found positive impacts on efficiency (defined as cost, time, and scope goals) due to increased use of agile methods. Resolving this debate is beyond the scope of this paper. Instead, we focus on the *identification of development method* as a variable for investigation.

Customer satisfaction benefits from agile projects are possibly less controversial than cost and schedule benefits. Agile's iterative nature, flexible change management, and continual customer feedback lead to customer satisfaction. For example, Serrador and Pinto examined 1002 projects spanning multiple countries and industries and found that agile methods had a positive effect on customer satisfaction in private sector projects [14]. Similarly, Jorgensen [6] found that projects employing agile methods had positive effects on project success in the form of client benefits.

While the commercial sector has employed agile methods for over 20 years, the adoption of agile methods in the public sector has been slow [25]. Worldwide, military acquisitions have tended to rely more on traditional development methods such as the waterfall method. However, that tendency is slowly changing, and the change is seen in government reports, such as McQuad et al.'s discussion of agile as a preferred approach to software development [3]. Additionally, outcomes in a limited number of military projects have contributed to the change. For example, the ISPAN program shortened cycle time by 45 months [27], while Kessel Run's tanker planning tool has saved in terms of logistics and fuel costs [28]. While these individual projects are sources of anecdotal evidence that seems promising, the need for larger studies comparing the military sector's agile and non-agile project outcomes is readily apparent. This paper is intended to help fill that gap.

To summarize thus far, the chosen development method may be an important factor for project success. While the private sector has long since shifted to agile methods in IT projects, the public sector in general and the military in particular have lagged behind in the adoption of such methods. Data from multiple NATO projects are now available to explore the impacts of this change. Consequently, it is now possible to analyze military IT projects that employ traditional methods in comparison with those using agile methods. In the next section, we shift our attention to the execution phase of the project by examining critical success factors.

2.3 Critical success factors

The program management literature on critical success factors (CSFs) supports and informs the development of several independent variables that are analyzed in this study. While "success" has been interpreted by researchers in various ways in the program management literature, this paper follows the works of Pinto and Slevin [4],[5] and Pinto and Prescott [6] (as mentioned in Section 1, the Introduction), in which success is regarded as meeting project budgets, schedules, and customer satisfaction/client benefit. Identification of CSFs facilitates focus on elements that are key to a project's success. These factors vary across businesses and industries. However, identification of commonalities in commercial and military CSFs allows for a comparison baseline for investigating the unique IT military projects in this study. Thus, this study incorporates CSF findings from the literature into the formulation of independent variables for analysis of cost, schedule, and client benefit.

The ubiquity of CSFs is well documented in the literature. CSFs have been shown to be important in a wide range of commercial industries, from biotechnology [29] to manufacturing [17]. CSFs in the software and IT industries are germane to this article. The literature contains many conceptual models of software CSF, such as those by McLeod and MacDonell [15], Ahimbisibwe et al. [30], and Purna Sudhakar [31]. In addition, empirical studies of software project CSFs have been conducted in various countries, including Turkey [10] and Norway [8],[9], as well as many other countries for which datasets have been generated, such as the data held by the International Software Benchmarking Standards Group (see also Lavazza et al. [32]). This multicountry, IT-specific CSF literature is particularly relevant for this study, which examines a cross-section of NATO country projects.

The vast amount of research conducted on commercial IT project's CSFs to date has resulted in meta-analyses that summarize the literature. In one such study, Nasir and Sahibuddin [33] analyzed 43 research articles in an attempt to understand the critical factors that influence IT project success. They identified 26 CSFs, which they divided into three categories: people factors (7), process factors (16), and technical factors (3). Of these, five factors were observed in more than 50% of the researched literature and therefore deemed the most important factors (Table 1).

In contrast to the robust literature from the commercial sector, there is a relative dearth of CSF literature reporting analyses of military IT projects. This limited literature includes CSF contributions by Goljan [28, p. 261] on evolutionary acquisition and May [34] on military software project failure characteristics. However, perhaps the most robust analysis is by Tishler et al. [12], who identified CSFs from an analysis of 110 military projects executed in the 1980s and 1990s. Of these, the five most common CSFs are listed in Table 1. To the best of our knowledge, there has not been an update on military IT project CSFs since the work of Tishler et al. in the 1990s [12]. Filling that gap of more than 20 years was part of the motivation for this study.

Table 1. Key CSFs in commercial and military projects

Commercial CSFs (source Nasir and Sahibuddin [33])	**Military CSFs** (source: Tishler et al. [12])
1. Clear requirements and specifications	1. The more critical the perceived need, the greater the chance of success
2. Clear objectives and goals	2. Amount of customer follow-up
3. Realistic schedule	3. Clear and reasonable scope
4. An effective project manager	4. Clear requirements early in the project
5. Support from top management	5. Professional qualifications and high motivation of the development team

Table 1 highlights the similarities between the CSFs in studied commercial and military projects. In the 1990s, there was significant overlap between the CSFs for commercial software projects military development projects [12],[33]. Thus, the literature points to the following common CSF independent variables: *requirements*, *objectives*, *expertise*, and *involvement*. They are the CSF variables of interest in this study. In summary, while there is a vast body of literature on commercial IT project's CSFs, there is a relative dearth of CSF literature on military projects in general and even less on military IT projects in particular.

Moreover, within the existing literature, it is important to note that *human factors* [7],12],[20] are identified as the most important for IT process success. This means that CSFs are within the control of the project team. However, the extent to which NATO countries are incorporating these CSF into their IT projects is an open question. We identify the top human factors from the literature as *requirements*, *objectives*, *expertise*, and *involvement*, and we seek to investigate their effect on military IT project success.

2.4 Project size and contract type

Military projects are often complex. Quantifying the complexity of a project with a universal metric can be difficult. For example, technology readiness levels (TRLs) are a metric used by some military organizations as a maturity assessment tool and hence as an indicator of complexity [35]. Cost and schedule growth have been found in projects that attempted to integrate technologies before they were mature [36],[37]. This makes TRLs an appealing variable for investigating complexity. Unfortunately, the documented issues with TRLs [33], and perhaps more importantly, the lack of consistent TRL reporting by military project managers, made their usage in our research unfeasible.

Another proxy for complexity is size [16]. In IT projects, the sheer number of software lines of code is one such measure of size [38]. A Defense Science Board report [38] published in 2018 discusses this relationship between complexity and growth in lines of code. The report illuminates the dramatic increase in avionics lines of code from 135,000 for the F-16A in 1974 to over 29.5 million for the F-35 joint strike fighter in 2017. Given that the greater the amount of code, the more dollars a project can typically be expected to cost, project size was examined as an independent variable examined in the study.

A final variable frequently discussed in the project performance literature is contract type. Project success may be achieved in part by selection of the appropriate contract type [9],[39],[40]. In military projects, the contracting options range from fixed price to time and material. While fixed-price contracts theoretically should contain costs and schedule more effectively than cost plus and/or time and material contracts, the empirics are often at odds with the theory in previously studied military projects [39],[41].

Narrowing focus the literature review to software projects provided further insights into the relationship between contract type and project success [42]. Jørgensen [6] found that avoiding fixed-price contracts was connected to success in the delivery of client benefit. Kalnins and Mayer [43] found that when estimating costs prior to the award of a contract was difficult, a time and material contract was preferable. Dey et al. [44] found that time and material contracts performed better in complex projects when monitoring was efficient, but fixed-price contracts were better suited to simple software projects with short durations. Thus, due to the prominence of contract type in the literature it is included as an investigated variable in this study.

3. Method

3.1 Data collection and the selected projects

We held interviews with 25 project managers (PMs) with in-depth knowledge of selected projects. These interviewees were selected according to their availability. The interviews were held in 2020 and 2021, and all were held in English except for those with the PMs of Norwegian projects. The latter were later translated from Norwegian to English by the Norwegian researcher with assistance of native English researchers in the research team. We developed an interview guide, together with the help of an extended group of researchers, many of whom had more than 10 years of experience from different roles within IT projects and cost estimation of software development. To avoid any risk of bias towards either the most successful or largest and most noticeable IT projects in our study sample, we asked the interviewees to select the last IT project they were involved in and that had been completed. The role of the PM had thus been to secure the success of the IT project. To limit any incentives to exaggerate the success, the researcher emphasized the confidentiality of the study, especially in the case of senior management. In order to study actual relationships between project characteristics and success, we needed to address specific projects. The focus on specific projects also enabled a strengthening of the analysis due to additional information from those projects (e.g. information obtained from other project personnel and/or project documentation). The interviews lasted 1–2 hours and were conducted digitally or in person when possible. Although the short questions could have been sent by email to be filled in, the sit-down interviews allowed us to clarify points in the interview guide and to ask follow-up questions on topics of particular interest. The interview guide consisted of both short answer questions, to enable quantitative comparisons, and follow-up questions for the interviewees to provide longer answers on topics in cases when they were unsure or had additional remarks. To ensure comparability in the interviewees responses we used a drop-down menu in Excel with pre-defined categories for the short-answer questions. One of the fixed items in the menu was “don’t know or fill in,” which was intended to capture responses outside our pre-defined categories. Given the increasing prevalence of agile software development methods in military IT projects, we included specific questions regarding development methods in our interview guide. The interview guide is provided in Appendix A.

The projects selected by the interviewees (i.e., the last project they had been involved in) and that formed our dataset were all IT projects within either a NATO country or a NATO agency. The represented NATO countries were Norway, the USA, Canada, and the UK. Additionally, there were four projects from two NATO agencies. In total, 25 projects were studied. The size of the projects was in the range of 0.8–351 million USD, and all projects were either in their finalization phase or had recently been completed when the data were collected in 2020 and 2021. One of the projects was cancelled during the execution phase and failed to deliver any client benefits. As our approach was to ask about the last IT project in which the interviewees had been involved, we decided to include the cancelled project as a failed IT investment for the relevant part of the general population. The projects in our dataset had the special feature of being military IT projects in which the aim was to function on an operational platform and/or to enable communication and interaction across different levels of classification. An overview of the projects is presented in Table 2.

Table 2. The studied projects

ID	Project information	Budget* USD million
1	NATO agency, software acquisition, agile (communications)	12
2	NATO agency, software acquisition, agile (communications)	3
3	NATO agency, hardware with software acquisition, waterfall (communications)	15
4	NATO agency, hardware with software acquisition (bespoke), agile	0.8
5	Norwegian, hardware with software acquisition, agile (communications)	44
6	Norwegian, hardware with software acquisition, waterfall (commodity IT)	45.2
7	Norwegian, hardware with software acquisition, waterfall (communications)	36
8	Norwegian, software acquisition, COTS** with configuration, waterfall (commodity IT)	71.6
9	Norwegian, hardware with software acquisition, waterfall (commodity IT)	45.9
10	Norwegian, software acquisition, COTS with configuration, waterfall (commodity IT)	12.9
11	Norwegian, hardware with software acquisition, waterfall (commodity IT)	8.3
12	Norwegian, software acquisition, COTS with configuration	5.5
13	Norwegian, hardware production acquisition (communications)	40.9
14	Norwegian, bespoke software acquisition, incremental (communications)	36.7
15	US, software acquisition, COTS with configuration, waterfall	6.5
16	US, software acquisition, COTS with configuration, waterfall	22
17	US, software acquisition, COTS (specialized IT)	10
18	US, hardware with software acquisition, waterfall (commodity IT)	67
19	US, software acquisition, waterfall	45
20	NATO agency, software acquisition, agile	2
21	NATO agency, hardware acquisition (communications)	351.5
22	Canadian, software acquisition (configuration)	97.2
23	Canadian, hardware with software acquisition, agile (communications)	286
24	Canadian, software acquisition, agile (COTS with configuration)	128.4
25	Canadian, software acquisition	35.9

*For comparison across time and countries/agencies, all monetary amounts are indexed to USD millions in 2020; **Commercial off-the shelf

3.2 Source triangulation

Information on the IT projects was mainly sourced from the interviews and recorded in an Excel spreadsheet. Additionally, notes were taken in the case of longer answers. In addition to the interviews, project documentation was used, and other relevant project personnel were asked follow-up questions when needed. At least two researchers went through the collected information in order to detect and solve problems of ambiguity in the answers. For the analysis, quantitative data were gathered and recorded in an Excel spreadsheet. This allowed the researchers to analyze the spread of the short answers, together with the documentation of the longer answers.

3.3 The analyses

For the main part of our analysis we adopted an exploratory approach wherein our goal was to learn more about how to identify what project characteristics affect success. The analysis of quantitative data from the interviews was based on descriptive statistics, as well as on formal statistical testing when deemed appropriate. For relationships of special interest, we applied the Fisher's exact test to determine whether there were non-random associations between two categorical variables. In our dataset this was, for example, differences in the proportions of our success variables across our categorical variables on project characteristics. The Fisher's exact test was considered suitable because of our limited number of observations ($n = 25$). Significant findings above a threshold of 95% ($p < 0.05$) are reported in Section 4.

For our three success variables of benefit, cost, and time, we analyzed the interviewees' perceptions of the project performance, not an overall objective measure of the project's success. For the variables time and cost, it was to some extent possible to check statements compared with project documentation, but no such objective and precise measures were documented for delivery of client benefit. However, we advocate the usefulness of considering the three success variables together. A project that delivers the planned amount of client benefit but with a cost overrun of 30% will perform better overall than a project that stays on budget but delivers only 50% of planned client benefit. According to Ward et al. [7], sit-down interviews enable researchers to clarify terms such as client benefit and ask follow-up questions to understand whether, for example, the client has actually used the software in operations. In the next section (Section 4), we supported the findings with statements given as part of the longer answers in the interviews, where relevant.

4. Results and discussion

4.1 Project success

The overall results of the analysis are presented in Table 3. The results relating to cost and time performance with a negative sign indicate an "underrun" (i.e., the projects were finalized either at a cost lower than the budget or before the schedule). The interviewees were able to choose from several categories (see Appendix A for the full questionnaire) when stating the percentage that constituted the best fit for their project. The main emphasis in the presentation of our results is on the main motivation for the IT investment, which was the delivery of client benefits. The mean project delay in our dataset was substantial (28%). The mean cost overrun (8%) was lower than found in previous studies of public investments [45]–[4648 and studies of IT projects, especially one reported by Flyvbjerg and Budzier [49], for which an average cost overrun of 27% was found. The following quotation from one interviewee illustrates the possible difference between accuracy of cost estimation and estimation of project schedule: "This is acquisition of civilian IT solutions and the cost estimation should therefore be easy. It is the operation and management phase that is the challenge."

With regard to the success variable "client benefit delivered," the mean projects delivered just over 80% of planned benefit, a share that corresponds closely to some previous findings concerning success in the delivery of client benefit [9],[50]. Our mean percentage was somewhat higher than the percentages reported by Flyvbjerg and Budzier and [49], for which IT projects experienced a mean shortfall of 29.3% of planned benefit. For all three variables, the spread was quite wide over the maximum and minimum values, as reflected in the standard deviation (SD) shown in Table 3. Our overall finding that the military IT projects experienced challenges on all three success variables fits well with previous findings relating to challenges in IT projects in the public and private sectors. This is also illustrated by the following quotation from one of our interviewees regarding possible optimism bias when planning such projects: "[The] Government does a poor job of understanding the full scope of the effort. This [underestimating the full scope] is often done to buy into the project to get it approved."

Table 3. Results of the analysis of three success variables: time, cost, and client benefit delivered

Success variable	Mean	Median	Max.	Min.	SD
Client benefit delivered, n = 21	82%	100%	110%	0%	28%
Cost deviation (cost overrun), n = 24	8%	0%	50%	-50%	26%
Time deviation (delay), n = 22	28%	40%	50%	-50%	26%

The distribution of answers relating to our main success variable of "client benefit delivered" is shown in Figure 1. The largest portion of projects (24%) was in the category of "All client benefits were delivered as planned." One of the interviewees in this category stated the following regarding how their project was planned and organized: "Team size is set by expert judgement of best delivery mechanism. Then, duration is set by the architect and agile expert, and Dev[elopment] team. During project implementation, we evaluated velocity and backlog size quarterly."

For 20% of the projects, the interviewees indicated that more than planned benefits were delivered, and we set this finding as a 110% result for those projects, to differentiate between the projects for which the interviewees indicated that all planned client benefits were delivered (100%). For the projects in which more than planned client benefits were delivered, one of the interviewees stated that they had made changes in scope to add extra functionality in the project. However, as shown in Figure 1, a large percentage of the projects experienced a shortfall in delivery of client benefits. Also, for four IT projects in our dataset (16% in Figure 1) the interviewees were unable to state how much client benefit had been delivered. When asked to elaborate, some interviewees pointed to lack of maturity in the technological solutions provided and/or that the project had been cancelled before finalized.

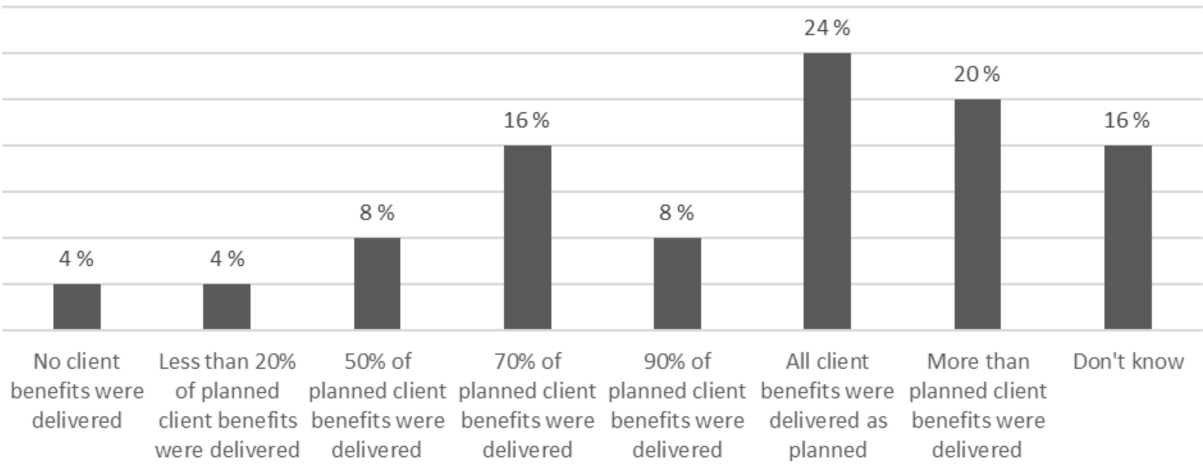

Figure 1. Distribution of delivery of client benefits in the studied projects (n = 25)

The relationship between cost overruns and delays in projects has previously been discussed the literature [51]. For our three success variables, the strongest correlation was found between time and cost (0.31), as shown in Table 4. This was a positive correlation, implying that cost deviations increase with time deviations (delays). it should be noted that this correlation does not imply any causation between the variables. The correlation between delivery of client benefit and cost was weakly positive (0.10). Similarly, the correlation between client benefit and time was low, but in the opposite direction (-0.11), meaning that client benefit increased with a shorter delay. A similar low correlation between delivery of benefits and budget control (0.2) is reported by Jørgensen [9]. Together, both our findings and Jørgensen's finding highlight the importance of including delivery of benefit when analyzing project success. In this regard, note that our finding of low correlation between the three success variables does not necessarily imply that they were not connected, and therefore they should be seen in relation to each other when discussing overall project success. Accordingly, we include all three as relevant in our discussion of success in military IT projects in this paper.

Table 4. Correlation between success variables

Success variable	**Client benefit delivered**	**Cost deviation (cost overrun)**
Cost deviation (cost overrun)	0.10	–
Time deviation (delay)	-0.11	0.31

Since our three success variables did not appear to have a large impact on each other, we focused on other parameters and characteristics that might affect success in military IT projects. These are discussed in the following Subsections 4.2–4.5.

4.2 Software development method and project type

The choice of agile as a software development method has previously been found to have a positive effect on project success [9]. The projects in our dataset were divided roughly equally according to which PMs reported the use of the agile development method and which PMs reported the use of traditional methods, such as waterfall. The decision to use the agile method entails some changes and more frequent involvement of stakeholders in the project, such as the end client, compared with the use of traditional methods. This is illustrated by the following quotation from one PM: "[There are] varying roadmaps in agile. All stakeholders must be engaged up-front and roadmaps aligned. Cannot meet expectations of 'delivered to OUR customers' if there's another process before it can be used operationally." Another interviewee pointed out that agile practices are still quite new to many parts of the military sector in NATO countries: "It is important to stick to the civilian market, to keep up with the civil industry, since agile practices are more adopted there."

On average, a project with agile as the development method delivered 14 percentage points higher client benefits (Table 5). Although the delay was 7 percentage points lower, the agile projects had on average almost 10 percentage points higher cost overruns. This finding might illustrate that the fundamental challenge faced by the PM, which is to score well on all three success variables at the same time, is also present when choosing agile development methods in IT projects.

Table 5. Development method and project success

Development method	**Client benefit delivered (mean), n = 19**	**Cost deviation (cost overrun, mean), n = 21**	**Time deviation (delay, mean), n = 20**
Agile	86%	10%	25%
Traditional methods (e.g., waterfall)	72%	0.4%	32%

When we applied a two-sided Fisher's exact test to identify differences in proportions in our success variables, we found a statistical difference between agile and non-agile methods on cost deviation ($p = 0.023$), which meant we could reject the null hypotheses of the means being equal.

A large portion of military IT projects have deliveries in the form of both software and hardware. In our dataset, these "combination" projects constituted 44%. As shown in Table 6, projects with a hardware component had on average higher mean client benefits delivered, as well as better budget performance, but they were delayed more compared with other projects. One way to interpret this result is to take into consideration that software components can be more challenging to estimate up front compared with hardware. Examples from the defence sector are the US Air Force's F-35 program and the substantial growth in software coding reported by the US Government Accountability Office [51]. In addition, in a previous study of military IT by Berg et al. [53] found that bespoke solutions were as high as 65% within the Norwegian portfolio. A high rate of new development can affect the risk of shortfall in success. Tangible goods such as hardware can be more straightforward to procure, as can commercial off-the-shelf (COTS) solutions.

Table 6. Project type and success

Project type	Client benefit delivered (mean), n = 21	Cost deviation (cost overrun, mean), n = 24	Time deviation (delay, mean), n = 22
Software only	65%	12%	25%
Hardware with software	99%	1%	34%

4.3 CSF: projects' requirements and objectives

Mohd and Shamsul [54] list clear requirements and objectives as the first two critical success factors regarding software. To see how these characteristics affected military IT projects, we asked whether the projects' requirements and objectives were clear, as these can be seen as prerequisites for successful projects. The results are shown in Table 7.

Table 7. Projects' requirements and objectives

Were the projects' requirements clear and well specified?	**Client benefit delivered (mean), n = 20**	**Cost deviation (cost overrun, mean), n = 22**	**Time deviation (delay, mean), n = 21**
Yes	82%	-8%	23%
No	81%	21%	32%
Were the projects' objectives clear and well specified?			
Yes	92%	6%	23%
No	52%	11%	45%

Clear requirements seemed to have more effect on cost and time deviations than delivery of client benefit. The projects' requirements were more concerned with the technical deliveries of the project and possibly less in relation to achieving overall benefits for the client. The need for clear objectives was stated by one interviewee: "We always start from scratch with the new demands from the military user. A lot to gain from establishing a common demand/need and requirements. We don't share experiences. The experts are to be used everywhere. We lack resources." When applying a two-sided Fisher's exact test to identify differences in proportions for a 2×2 contingency table, we found a statistical difference between clear objectives (yes/no) on delivery of client benefit ($p = 0.05$).

4.4 CSF: expertise and involvement

Process characteristics in the form of expertise on how the project is followed up by the relevant stakeholders has been found to affect the success of IT projects [21],[55]. To capture how experience and expertise could influence the success of military IT projects, we asked the PMs to state their amount of relevant experience (years of experience within areas such as project work/IT/military acquisitions). We also asked the PMs to evaluate the expertise and degree of involvement of both the clients in the armed forces and the suppliers of the IT solutions. The results are in Table 8.

Table 8. Project managers' experience and project success

Project manager's experience (years)	Client benefit delivered (mean), n = 21	Cost deviation (cost overrun, mean), n = 20	Time deviation (delay, mean), n = 21
1–10	78%	18%	25%
10+	83%	13%	36%

We found an average increase of 5 percentage points in the delivery of client benefits in cases where the PM had over 10 years of experience. The following statement from one of the interviewees supports the possible beneficial effect of having an experienced PM: "The PM must understand functionality of system and have experience, have a gray beard, [and] technical understanding."

Also, cost overruns were reduced by an average of 5 percentage points in the group of projects with more experienced PMs. However, when we looked at our third success criterion (time deviation) in that group, we found that the mean delay had increased by 11 percentage points. Together, these results do not suggest any clear learning effects where increase in PMs experience would improve overall project success. Since our focus was on the PM, the result might be different if we had included the experience of the entire team in our analysis.

Theoretically, the inclusion of clients throughout the project and their previous experience with similar IT projects is important for project performance. The emphasis on enhancing this connectivity is part of the reason agile software development has been adopted as a primary approach in the commercial sector. Regardless of the software development method, it is important to examine the dimension of client involvement [3],[56]. Therefore, to capture this part of the software development process and how it might affect success, we asked the PMs how they perceived the degree of expertise and involvement from the client. The results are shown in Table 9.

Table 9. Degree of clients' expertise and involvement related to project success

How good do you consider the clients' expertise was in terms of similar experience and general track record?	Client benefit delivered (mean), n = 21	Cost deviation (cost overrun, mean), n = 22	Time deviation (delay, mean), n = 22
Poor/very poor	88%	4%	30%
Acceptable	88%	4%	31%
Good/very good	77%	8%	25%
Did the client follow up sufficiently throughout the project?			
No	74%	16%	31%
Yes	88%	-1%*	26%
How good do you consider the supplier's expertise is in terms of similar experience and general track record?			
Poor/very poor**	90%	0%	25%
Acceptable	73%	7%	15%
Good/very good	84%	6%	33%

*A negative number means a cost underrun (i.e., final costs below the initial budget); **There was only one observation in this category and therefore the results should be interpreted with considerable caution

The projects with good or very good client expertise (as considered by the PM) had a lower mean delivery of client benefit and a higher mean cost deviation compared with the projects in which the client expertise was "acceptable" or "poor/very poor." This is a somewhat surprising result, since we had expected client expertise would have a positive influence on project success. One point for discussion concerning this result is the case of “gold plating” resulting in highly bespoke solutions in military IT projects, and how it can have a negative effect on success. According to findings from the study of IT project management by Nelson [57], this phenomenon can apply both to requirements and to the developer. In our data, the risk of “gold plating” of requirements might have been higher if the client expertise was good.

The results relating to our question of how the actual follow-up was from the client revealed a clear positive tendency for all three success variables. We observed a 14-percentage point increase in the delivery of client benefits for the group of projects in which the clients followed up throughout the project compared with the projects in which the client did not follow up. Only one interviewee stated that the supplier’s expertise was poor/very poor. When we compared results for projects in the two remaining groups (“acceptable” and “good/very good”), we found that projects with “good/very good” supplier expertise had an 11 percentage points higher mean delivery of client benefits and performance on cost was close to equal, but the projects were more delayed.

4.5 Project size and contract type

The management of larger projects can involve a higher risk of underperformance [58]. To see how our success variables were distributed between projects of different sizes, we divided them into five groups according to monetary value. The results listed in Table 10 show a tendency towards increased cost overruns and delays for larger projects. For delivery of client benefit, the distribution was quite similar among the groups, with the exception of the mean of 90% for projects in the range of 10–50 million USD. In other types of military investments, a large project can simply mean that the acquisition consists of a large quantity of new material and that the project itself is not categorized as high risk. With regard to IT, the results in Table 10 show that the projects over 100 million USD delivered the lowest amount of client benefit. It might be that the effort needed to produce client benefits increases with the size of projects due to complexity in the form of increased amount of stakeholders and organizational changes needed. Still, our analysis did not reveal a clear answer as to whether complexity explained the results shown in Table 10.

Table 10. Project size and project success

Project size	**Client benefit delivered (mean), n = 21**	**Cost deviation (cost overrun, mean), n = 24**	**Time deviation (delay, mean), n = 22**
< 10 million USD	72%	0%	25%
10–50 million USD	90%	9%	30%
50–100 million USD	76%	13%	25%
> 100 million USD	70%	17%	40%

One characteristic previously reported for successful software projects is the avoidance of fixed-price contracts [9]. In general, acquisitions of military materials can face challenges when beneficial contracts are negotiated, due to market regulations and either monopolistic or few suppliers of military materials. When it comes to IT, the possibility to benefit from more suppliers from the private sector exists, also with a possible increase in bargaining power to prepare the best type of contract for the armed forces. For all success variables in our study, there was an approximately equal distribution of 50% of the projects using firm-fixed-price (FFP) contracts and 50% using time and material contracts. Not surprisingly, cost deviations were almost zero for firm-fixed-price contracts (Table 11), but those projects also experienced more delays. The difference in delivery of client benefit was smaller between the two types of contract, but in contrast to previous findings [9], fixed-price contracts performed on average better than time and material-based contracts in our dataset.

Table 11. Contract type and project success

Contract type	Client benefit delivered (mean), n = 21	Cost deviation (cost overrun, mean), n = 23	Time deviation (delay, mean), n = 22
Firm-fixed-price	84%	0.4%	35%
Time and material (per hour)	79%	13%	20%

5. Conclusion

Military IT projects deliver solutions that need to perform flawlessly under hard real-time constraints in military operations and training, in contrast to commercial sector projects, where failures have financial and organization consequences, but national security and lives are not directly at stake. Commercial sector best practices and critical success factors (CSFs) therefore inform the military sector, but adaptation in the military arena may require changes along some dimensions. Articulating the specific changes between the two sectors is beyond the scope of this paper, as the focus is on a higher level of analysis in order to identify the characteristics of successful military IT projects themselves. The results provided in this study are a novel contribution to the body of knowledge within a less studied area of public IT acquisitions.

We started our empirical investigation of data by looking at the correlation between our three success variables—time, cost, and delivery of client benefit—and we found the correlation was low. Regarding delivery of client benefit, the military IT projects in our dataset delivered on average 82% of planned benefit. This finding is in accordance with previous findings reported in the literature on civilian and public IT project performance. With respect to our first research question (How does the choice of software development method contribute to success in military IT projects?), our findings support those of previous studies in which the use of the agile method delivered client benefits “better” than did traditional methods.

With regard to our second research question (How do critical success factors *requirements*, *objectives*, *expertise*, and *involvement* contribute to success in military IT projects?), we found supporting evidence that CSFs reported in the literature were of importance for project success in the military IT projects in our dataset. In particular, project manager experience and how much the client followed up during project implementation seemed to have a positive effect on project success. Lastly, clear and well-specified objectives in the project had a statistically significant effect on project success in the form of delivery of client benefits.

Regarding our third and final research question (How does project size and choice of contract type contribute to success in military IT projects?), we found that medium-sized projects performed better on delivery of client benefits compared with both large and small projects. The military IT projects in our dataset delivered better regarding cost and client benefit on fixed-price contracts, but they were more delayed than the projects that were on time and the material contracts.

Our review of the literature revealed a consistent set of critical success factors. The presence (or lack thereof) of the same factors in our study was empirically found to be a driving force in the success of the military IT projects, and we can therefore suggest some practical implications. First, in projects where client benefit is the first priority, the selection of a project manager with vast experience is recommended. Second, our study revealed that clear and stable requirements remain crucial to project success in military IT projects. The practical implication is simply that taking the time in advance to define requirements pays dividends in controlling cost and delivering on schedule. Similarly, the third practical implication relates to client follow-up. Functionality that is not performing or requirements that are not being properly developed need early client feedback. Garnering this feedback early (and iteratively) improves project performance. Thus, requirements and client feedback go hand-in-hand in terms of improving performance.

The above discussion focuses on practical steps that can be taken *during* the project. There is, however, one other practical implication of our empirical study and it involves an activity *prior to project initiation*, namely the strategic decision as to what development method to employ. As discussed in Section 2, there is a movement toward agile software development in military projects. The findings from our empirical study support the call for more agile development. The projects that applied agile principals had better results in terms of client benefit and schedule. Hence, we suggest that military IT projects should be approached by using agile methods when the aforementioned attributes (client benefit or schedule) are most important to the organization.

5.1 Future research

The focus of this study is the characteristics of successful military IT projects. Project success and project work are both established areas within project management. At the same time, many military operations involve project work to a large extent. When new software is adapted in a military organization, one interesting question for future research that arises is whether or not the principles that guide more conventional military work are compatible with the principles applicable to modern IT projects. Although this study adds more knowledge of the adaption of agile development methods in a military context, military IT acquisitions have been more likely to rely on traditional development methods such as waterfall, in contrast to the commercial sector. Given that the adaptation of agile is relatively new in the military environment, there is a need for more empirical work comparing the military sector's agile and non-agile IT project outcomes.

5.2 Limitations

The data in our study were derived from a limited number of military IT projects, and the interviewees were selected based on availability. Therefore, our results should only with great caution be transferred to other contexts. Furthermore, IT projects are complex processes involving different stakeholders, as well as different types of competence and deliveries. To address our research questions, we chose a number of characteristics that we considered relevant, but our analysis had limitations in that important elements might have been omitted, and/or we simplified correlations between cause and effect.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available, due to military restrictions and classifications applying to the IT projects studied. Upon request, a subset of the data in which classified information has been removed can be provided.

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Appendix A. Survey questions

The survey questions were divided into groups A to F, according to the part of the research to which they related. Some questions had several sub questions, each with a unique question identity. To ensure the answers would be comparable, each question had a drop-down menu with standardized choices. All questions had an “other” or “don’t know” option, as well as an option to give a more detailed answer in addition to the standardized short answers.

Question Group A: Project characteristics

Question ID	Interviewee	Question
A-1	PM	What was the planned monetary size of the project/what PM can distribute (budget)
A-2	PM	What type of IT acquisition was this project?
A-2-1	PM	If your answer is “Software,” please specify
A-2-2	PM	If your answer is “Hardware only—Development,” please specify
A-2-3	PM	If your answer is “Hardware only—Production,” please specify
A-2-4	PM	If your answer is “Hardware only—COTS,” please specify
A-2-5	PM	If your answer is “Hardware with Software,” please specify
A-3	PM	If the IT acquisition contained software, what type of software development method was used in this project?
A-3-1	PM	If the IT acquisition contained software development and the development method was agile, did you have working software delivered to clients in each iteration?
A-3-2	PM	If the IT acquisition contained software development and the development method was agile, could the development team change the requirements based on client feedback?
A-4	PM	Do you consider this a complex project? The project must contain *one or more* of the following four characteristics: (1) laborious (the amount of novel (as opposed to routine) work required), (2) a large number of unknown quantities, (3) a large number of systems—in particular, legacy systems—with which the project has to integrate, (4) the project has to achieve a large number of objectives.
A-5	PM	How well did the project perform regarding costs?
A-6	PM	How well did the project perform regarding time schedule?
A-7	PM	How well did the project perform regarding client benefit (outcome)?

Question Group B: Expertise/knowledge

B-1	PM	How good do you consider the clients' expertise?
B-2	PM	How good do you consider the *supplier's* expertise in terms of similar experience and general track record?

Question Group C: Cost method

C-1	PM	What type of method was used to estimate the costs of this project?
C-2	PM	What tool was used to estimate the cost of this project?
C-3	PM	How do you consider the data availability for conducting the cost estimation (i.e., was it sufficient)?
C-4	PM	Do you consider the O&M costs to be accounted for in a satisfactory manner when the acquisition started (the milestone, when one started spending money)?

Question Group D: Critical success factors (CSFs)

D-1	PM	Were the requirements clear and well specified?
D-2	PM	Were the objectives and goals of the acquisition clear?
D-3	PM	Was the schedule realistic?
D-4	PM	Did the client follow up sufficiently throughout the project?
D-5	PM	Was the project considered as critical?

Question Group E: Other relevant factors

E-1	PM	Did the acquisition have a clear plan for benefit management (BM)?
E-2	PM	If yes, was the BM plan followed in practice?
E-3	PM	What type of contract was used?
E-4	PM	Was there any change in scope/requirements?

Biographical notes

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