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Implementation Strategies for Modeling and Simulation in Military Organizations

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This is to certify that the doctoral study by

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Walden University
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Abstract

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MS, Walden University, 2017

M.Ed., Liberty University, 2013

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Doctoral Study Submitted in Partial Fulfillment

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Abstract

Some IT project managers working for U.S. military organizations are struggling to implement modern modeling and simulation (M&S) technology. Implementation strategies are needed to help IT practitioners deliver meaningful simulations and models that ultimately help senior leaders make logical and science-based decisions. Grounded in the extended technology acceptance model, the purpose of this qualitative multiple-case study was to explore strategies some IT project managers supporting U.S. military organizations use to implement modern M&S technology. The participants included 10 civil servants who successfully implemented modeling and simulation technology for military organizations located in the United States eastern region. Data was collected from one-on-one semistructured interviews (n = 10) and internal and external organizational documents (n = 12) provided by the participants. Data were analyzed using thematic analysis. Three major themes emerged: understand the true M&S requirements, incorporate subject matter experts throughout implementation, and anticipate and overcome persistent challenges. One recommendation is for practitioners to develop tasks and milestones to address these challenges at the beginning of implementation and add them to the project schedule. The implications for positive social change include the potential for successful implementation of models and military organizations' simulations to safeguard human lives.

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Dedication

I dedicate this doctoral study to my wife, Nicole Denise Taylor, without whom none of this would have been possible. Nicole, you have made me a better person in every way imaginable. My academic journey would have never begun if it were not for your love and encouragement. As my wife and an educator, you believed in me when I did not. You comforted me when I wanted to quit. Every paper, every late night and long weekend, I did it all for you. You are my only companion in this journey, and I love you with my entire heart.

To my honorable children Elijah, Anna, and Benjamin, you are my shining stars. Each of you is stronger and smarter than I will ever be. Everything you see me do, you can do better. God will help you accomplish your dreams if you love and trust in Him.

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Thank you to my committee. In addition to serving as my second committee member, Dr. Bob Duhainy guided me during multiple residencies, helped me choose my topic, and was a fantastic professor. Dr. Jon McKeeby was also my professor, in addition to serving as URR. Dr. McKeeby inspires his students by teaching what he has learned as the CIO of the NIH. And most of all, I can never thank my committee chair enough, Dr. Jodine Burchell. Dr. B is a true mentor who guides her fledgling researchers with patience and compassion. Dr. Burchell, you have taught and inspired me more than you know. You stood by me during the most challenging of times, and I will never forget that.

To my doctoral cohort, thank you to the ones who forged the way and proved it can be done. To those who are still swimming, never give up; the land is in sight. You are brilliant and worthy. No one can stop you now! Go team Burchell!

Last, I want to thank the amazing leaders at Marine Corps Systems Command who have supported me every step of the way. Thank you to my past supervisors, competency leads, and Workforce Development. To my current supervisor and professional mentor, Mr. Steve Howell, thank you for everything you do. You inspire me every day to be better.

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Section 1: Foundation of the Study

This doctoral study's primary objective was to explore the implementation of modeling and simulation (M&S) technology in military organizations with the intent of addressing a current gap in the available academic literature. Unlike other manufacturing or healthcare sectors, there is a lack of scholarly research studies dedicated to sharing strategies and best practices for M&S implementations in the military domain. In the following section, I will present the foundation of my study, which examines multiple aspects of the problem, to include a thorough review and analysis of the professional and academic literature.

Background of the Problem

For many years the United States Marine Corps (USMC) has acknowledged the importance of M&S technology. Recently, General David H. Berger, the 38th Commandant of the Marine Corps, reiterated the need to invest in M&S technology that Marines can use for a wide range of purposes that include training, wargaming, testing, experimentation, analysis, and proofing of new ideas and concepts (Berger, 2019). Support from senior military leaders is essential for the large-scale adoption of M&S technology (Sadagic & Yates, 2015), yet many federal Information Technology (IT) projects still fail because of cost and schedule overruns (GAO, 2016). Moreover, traditional project management techniques that monitor cost, schedule, and scope are insufficient for managing complex M&S efforts that often produce intangible results (Jahangirian et al., 2017). According to Jahangirian et al. (2017), project managers lack strategies and techniques to quantify and successfully manage multifaceted M&S

projects. While senior military leaders call for the increased use of M&S technology, IT project managers face significant implementation challenges.

Compared to the private sector, government agencies often encounter additional hindrances related to IT project execution. The Government Accountability Office (GAO) has reported ineffective management and the inconsistent execution of best practices contributing to IT project failures (GAO, 2016). Studies publishing best practices for M&S implementation in the healthcare arena are available (Cucurull-Sanchez et al., 2019; Dahabreh et al., 2015; Visser et al., 2017). However, Jnitova et al. (2017) noted that essential details and best practices are consistently missing from military M&S studies. Even though practitioners can apply best practices from one domain to another in some situations, Tako and Robinson (2015) found that implementing M&S in healthcare was different from implementing M&S in manufacturing or the military. Similarly, Chaawa et al. (2017) found that with some M&S implementations, unique organizational aspects played an important role. The apparent lack of published best practices for implementing M&S technology in the military could be contributing to IT project failures. New studies focused on uncovering best practices, techniques, and strategies for implementing M&S technology in military organizations are needed.

Problem Statement

The Department of Defense (DoD) spends an estimated $2.5 billion annually on M&S projects that are facing hefty return on investment (ROI) scrutiny because of low use and a myriad of other factors negatively influencing implementation (Sadagic & Yates, 2015). Traditional project management techniques are insufficient for managing

complex M&S projects (Jahangirian et al., 2017). While in one instance, the Navy saved $240 million by implementing M&S assessments (Gilmore, 2016a), in a different joint services program, a required M&S test component has been delayed 8 years despite receiving an additional $250 million in funding (Gilmore, 2016b). The general Information Technology (IT) problem is that some U.S. military organizations struggle to implement modern M&S technology. The specific IT problem is that some IT project managers supporting U.S. military organizations lack strategies to implement modern M&S technology.

Purpose Statement

The purpose of this qualitative multiple-case study was to explore strategies some IT project managers supporting U.S. military organizations use to implement modern M&S technology. The target population was IT project managers working for three different military organizations in the United States' eastern region, who have successfully implemented modern M&S technology. The results from this study could add to the M&S body of knowledge by contributing modern implementation strategies that practitioners could use to address novel challenges. From a social change perspective, more successful M&S implementations can safeguard human lives when people cannot safely execute real-world military systems evaluations.

Nature of the Study

For this study, I chose to use a qualitative methodology. Researchers take advantage of qualitative research's investigative nature to uncover the participants' feelings, opinions, and experiences to provide real-life context and rich descriptions of the meaning behind the data (Bapuuroh, 2017). A qualitative approach was required

because human participants' opinions, experiences, and perspectives were needed to address my research question. Quantitative methods focus on preestablished variables and utilize numeric data and statistical analysis to test for relationships between the variables (Landrum & Garza, 2015). Quantitative methods that incorporate data from human participants tend to limit responses and do not address the meaning behind the canned answers (Bapuuroh, 2017), essential to my research. Likewise, mixed methods require numeric data and statistical analysis to test variables and should only be used by investigators when the research question demands it (Green et al., 2015). My research question's nature did not require a mixed-methods approach to produce detailed descriptions of the participants' feelings and opinions. Qualitative research leads to a deeper understanding of a phenomenon by incorporating multiple data sources that researchers can triangulate to increase the results' trustworthiness and credibility (Monem, 2015). The topic of investigation required a qualitative approach.

I chose a multiple-case study as the qualitative design for this study. Using a multiple-case study design allows the researcher to investigate multiple groups of participants to obtain a holistic understanding of a complex phenomenon by comparing the data across cases (Bapuuroh, 2017). My study's central research question required a multiple-case study design to obtain a real-world understanding of the organizational and managerial processes used by multiple groups of practitioners in separate military organizations. Phenomenology is more philosophical and strives to define the essence of a lived experience shared between a group of individuals (Priyadarshini et al., 2017). The diverse groups of IT practitioners supporting separate military organizations do not share a lived experience related to the research topic. Researchers use ethnography when the

shared culture of a large group of participants can adequately explain a phenomenon (Green et al., 2015). My study included a limited number of participants from different military organizations who did not share a culture relevant to the research problem. To obtain a holistic understanding of the complex phenomenon, I used a multiple-case study design to gather and compare data across cases.

Research Question

What strategies do some IT project managers supporting United States military organizations use to implement modern M&S technology?

Interview Questions

I used an interview protocol to administer the following open-ended questions and follow-up probes when needed.

1. What strategies have you used to implement M&S technology?
    - Which of these strategies was the most effective?
    - Which of these strategies was the least effective?
2. What challenges did you encounter, and how did you overcome them?
3. How do you know when an M&S implementation is successful?
4. Please briefly describe what you consider to be the most critical phases of M&S implementation.
    - What strategies, if any, were used to create conceptual models?
    - What strategies, if any, were used for verification and validation?
5. What process do you use to determine the most appropriate M&S methodology?
    - What are the most commonly used M&S methodologies?

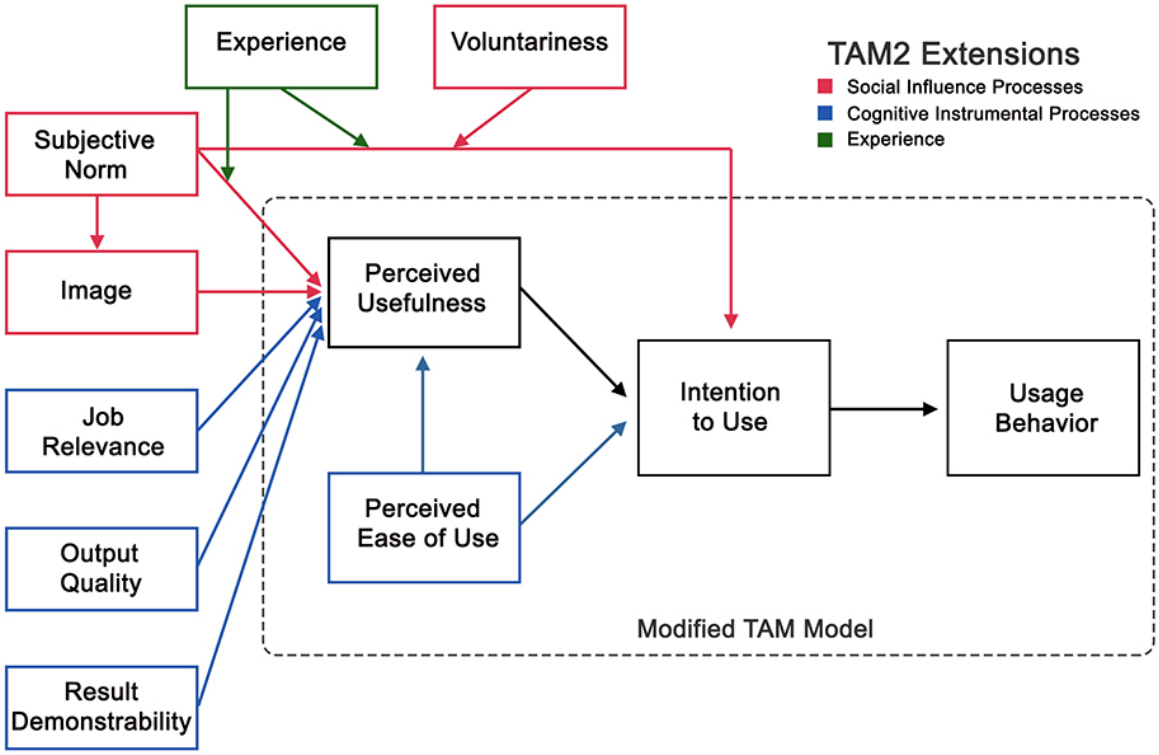
6. What strategies, if any, are used when selecting M&S development tools?
    - Are some M&S tools easier to use than others?
    - Have you faced restrictions on using desired M&S tools?
7. Do you have anything else to add that I have not asked about M&S implementation?

Conceptual Framework

The conceptual framework I used as a lens while conducting my research was the extended Technology Acceptance Model (TAM2), first developed by Viswanath Venkatesh and Fred Davis in 2000 (Venkatesh & Davis, 2000). The purpose of TAM2 is to illustrate specific user behaviors and attitudes towards computer-based information systems that researchers could use to explain technology acceptance (Venkatesh & Davis, 2000). The core tenets of TAM2 include Perceived Usefulness (PU), which is the extent to which a person believes a new piece of technology will enhance job performance; and Perceived Ease of Use (PEOU), which refers to the level a person believes using a new piece of technology would be easy (Venkatesh & Davis, 2000). The authors use the extension to expand PU by adding seven additional constructs that can be grouped by (a) social influence processes, (b) cognitive instrumental processes, and (c) experience. Please see Figure 1 for a diagram of TAM2 illustrating the seven additional constructs.

Figure 1

Recreation of the Modified TAM Model, With Seven TAM2 Constructs



Note. Adapted from Venkatesh and Davis (2000, p. 188).

The military has long recognized TAM's applicability on military research (Hathaway & Cross, 2016; Levy & Green, 2009), and more specifically, on modeling and simulation research (Sadagic & Yates, 2015). Because of the unique and demanding nature of military jobs, users expect new technological tools to be easy to use and significantly impact job performance. These considerations align with experience, job relevance, output quality, and results demonstrability. Military employees are often mandated to use specific tools, while in other situations, the employee can choose, which correlates to subjective norms and voluntariness. The core tenants and additional

constructs of TAM2 make the conceptual framework an ideal lens for investigating M&S implementation strategies used by military organizations.

Operational Definitions

Model: A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process (DoD, 2018, p 10).

Modeling and simulation (M&S): A discipline that comprises the development and use of models and simulations (DoD, 2018, p 10).

M&S implementation: The term M&S implementation can refer to the process of coding a model in computer software or the practical use of modeling and simulation results to inform a real-world decision (Brailsford et al., 2018).

Simulation: A method for implementing a model over time (DoD, 2018, p 10).

Assumptions, Limitations, and Delimitations

According to Creswell (as cited in Ellis & Levy, 2009), every scholarly study will include assumptions, limitations, and delimitations. Therefore, to improve the research findings' quality and the researcher's interpretations, all scholarly articles should report any identified assumptions, limitations, and delimitations (Theofanidis & Fountouki, 2018). The following sections report the identified assumptions, limitations, and delimitations inherent in my doctoral study.

Assumptions

Assumptions include different issues, ideas, or dispositions often taken for granted or considered pragmatic and well known (Theofanidis & Fountouki, 2018). Assumptions are often formed unconsciously but can lead to bias of perception and cognition, which in turn could constitute a vulnerability (Walsh, 2015). During the design

and planning of my study, I made several assumptions. First, I assumed that potential participants possessed M&S implementation strategies based on prior experience. Second, I assumed that the chosen inclusion criteria would lead to the selection of well-informed participants. Third, I assumed that potential participants would honestly answer each interview question based on personal knowledge, experiences, and successes.

Limitations

Research limitations are considered imperfections associated with the chosen method and design, which should not substantially impact the research findings' validity **(**Busse et al., 2016). Limitations are potential weaknesses inherent to research methodologies, hence often considered outside the researcher's control (Theofanidis & Fountouki, 2018). In the search for meaning behind the data, qualitative researchers must analyze and reduce large amounts of primary linguistic data so that patterns can be found and interpreted (Salmona & Kaczynski, 2016). There are no absolute rules that govern qualitative data analysis (Raskind et al., 2018). Instead, qualitative researchers must adapt, translate, and interpret to the best of their ability (Dai et al., 2019). For these reasons, my qualitative study is limited in that other researchers cannot truly replicate my customized methodologies and findings, which is not always the case with quantitative research. Another limitation of my study was the available time and energy needed to produce rich and thick descriptions indicative of high-quality case studies. Institutional time restraints imposed on all doctoral studies could limit the desired time a qualitative researcher spends gathering data. Last, my lack of training and experience conducting qualitative interviews could have limited my effectiveness.

Delimitations

Delimitation is a qualitative research term describing the process of intentionally creating boundaries such that a controlled research scope becomes useful to the study, instead of another limitation often reported as a *narrow scope* (Alpi & Evans, 2019). Adequately describing intentional delimitations can be of service to future researchers attempting to scrutinize whether the findings are relevant in other settings (Alpi & Evans, 2019). The delimitations of my study include (a) focusing on IT project managers supporting military organizations, (b) limiting the geographic location of potential cases to the eastern region of the United States, and (c) restricting the sampling techniques to purposive and snowball sampling. Intentionally limiting the participants to IT project managers supporting military organizations complimented my background, training, and experience, strengthening my interpretive insight as a qualitative researcher. Intentionally limiting the geographic location to the United States' eastern region increased the probability of conducting face-to-face observations and interviews.

Significance of the Study

The federal government has spent over $600 billion on IT projects in the past decade, but only a fraction of the increased productivity has been obtained compared to private industry (GAO, 2013). Federal IT projects frequently incur the cost and schedule overruns, with some projects failing or operating inefficiently, at the cost of billions of dollars (GAO, 2013). More specifically, over the past 2 decades, the DoD has spent $58 billion on programs that were eventually canceled; however, early operational assessments that implement M&S components can be used by IT managers to identify and address costly shortfalls (Gilmore, 2016a). Despite the potential benefits, underused

and underperforming M&S projects face early termination because of federal budgetary restraints (Sadagic & Yates, 2015). According to the GAO (2016), there is a need for more research studies designed to identify gaps in IT knowledge and skills so the government can develop strategies to address the gaps and increase IT projects' success rate. This study is significant to IT practice. The results can create strategies needed to help IT project managers implement M&S technology and increase future IT projects' success rate.

Society stands to benefit from this doctoral study's results because of the intrinsic elements of safety built into M&S technology that can lead to the preservation of human life. The literature provides examples of practitioners using M&S technology to save lives in diverse ways, from increased automobile safety (Salem et al., 2017) to developing techniques for restricting the carnage of an active shooter (Kirby et al., 2016). The United States military, with varying degrees of success, uses M&S technology to conduct realistic evaluations of military systems when safety is a concern. The gathered strategies needed to implement M&S technology successfully could have the potential to save lives and directly influence positive social change.

A Review of the Professional and Academic Literature

The purpose of this qualitative multiple-case study was to explore strategies some IT project managers supporting United States military organizations use to implement modern M&S technology. Despite the emergence of published M&S studies in the military domain, essential details needed to improve M&S implementations such as modeling methods, management strategies, and techniques for model validation and testing are missing from the literature (Jnitova et al., 2017). Previous research in the

military domain and other healthcare, manufacturing, and engineering sectors will be used to explore the research question and help build the study's foundation. The primary academic databases used in the literature search included IEEE Xplore; ACM Digital Library; Computers and Applied Sciences Complete; ProQuest Computer Science Database; Emerald Insight; and ScienceDirect. The initial keyword searches included various combinations of (a) *modeling and simulation,* (b) *project management,* (c) *military,* (d) *best practices,* (e) *strategies,* (f) *implementation,* and (g) *success factors*. Additional keywords were formed based on the relevant themes that began to emerge.

Of the 153 final sources incorporated into the analysis, 93% were reported as peer-reviewed and refereed by Ulrichsweb Global Serials Directory, with 85% published in the past 5 years. Of the 7% nonrefereed sources used, 10 were valuable government sources. The majority of studies included in the review are in line with M&S, conceptual frameworks, or qualitative research themes. Studies involving TAM2 shed light on the conceptual framework and how it can be used to investigate IT and M&S adoption. Articles predominantly related to M&S helped me understand the technology and define the significant themes in the literature. The literature review's final sections address modern considerations and best practices related to the qualitative study.

Extended Technology Acceptance Model

When researchers apply a proven theory as a theoretical framework, the model provides a blueprint or scaffold for the entire study (Moorley & Cathala, 2018). When used as a conceptual framework, concepts, in theory, guide the research and inform the findings (Moorley & Cathala, 2018). The extended Technology Acceptance Model (TAM2) was the conceptual framework used in this study. The framework was used as a

lens or guide while reviewing the literature and analyzing the future multiple-case study's qualitative data. The strengths of TAM2 lay in specialized elements of the framework that help investigators understand specific user beliefs, perceptions, and attitudes towards technology and information systems, which ultimately shed light on the probability of technology acceptance by a group of users (Venkatesh & Davis, 2000). When conducting a literature review, a critical analysis of the conceptual framework should be included, in addition to highlighting connections made to prior research on the proposed research topic (Rogers, 2016). The following sections explore the foundational framework of TAM2, extensions, limitations, alternative theories, and connections to recent military and M&S studies.

TAM

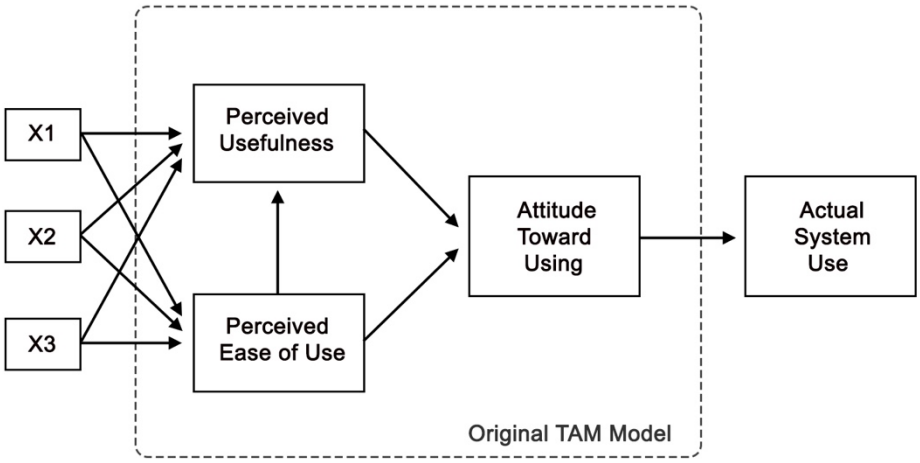
In 1985, Fred Davis developed the Technology Acceptance Model (TAM) for his Ph.D. dissertation, which was approved by the review board at Massachusetts Institute of Technology in February of 1986 (Davis, 1986). Davis initially used the Theory of Reasoned Action (TRA) as a guide when first developing the base TAM (Asampana et al., 2017; Justus, 2017; Marangunić & Granić, 2015). The influence attitude has on behavior (i.e., actual system use) was the major component borrowed from TRA (Marangunić & Granić, 2015). Additional behavior considerations, such as perceptions, were later added to TRA, resulting in the Theory of Planned Behavior (TPB; Justus, 2017; Marangunić & Granić, 2015). Davis, in turn, updated TAM to include Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) as the two main variables impacting a user's attitude, which was still considered to be the main determinant of actual system use (Asampana et al., 2017; Marangunić & Granić, 2015). In simple terms, PU represents

the perception that the technology would enhance job performance, while PEOU represents the perception that it would be easy to use (Justus, 2017; Marangunić & Granić, 2015). Additionally, Davis posited that PEOU would also influence PU in that technology deemed easy to use would be perceived as more useful (Hornbæk & Hertzum, 2017).

The final considerations added to the original TAM model were external variables related to features and system design that could influence user perceptions (Marangunić & Granić, 2015). See Figure 2 for a diagram of the original TAM model depicting the elements leading to actual system use, which included (a) external X variables, (b) perceived usefulness, (c) perceived ease of use, and (d) the user's attitude towards using the technology.

Figure 2

Recreated Diagram of the Original TAM Model



Note. Adapted from Davis (1986, p. 24).

Even though TAM came to be known as an effective model for explaining and predicting actual system use, consistent research findings demonstrated that more recent extensions

to PU more clearly explained usage intention rather than user attitude (Asampana et al., 2017; Marangunić & Granić, 2015). Inadequate empirical evidence eventually led to the removal of attitude in TAM2 (Rajanen & Weng, 2017), which constitutes valid consideration for utilizing the extended model. Therefore, the authors used the core expansions in TAM2 to replace attitude with intention and better define the generic external X variables with seven well-defined factors shown to impact PU and usage intent. While past research has shown that TAM can be used to account for up to 40% of the variance in usage intent, Venkatesh and Davis (2000) found that TAM2 can account for up to 52% of the variance for usage intent and up to 60% for PU.

Extensions

Figure 1 shows the TAM2 model's diagram depicts the seven extensions that have been grouped by social influence processes, cognitive instrumental processes, and experience. In TAM2, PEOU is a cognitive instrumental process. An observable relationship with PU led to each extension's creation (Rondan-Cataluña et al., 2015).

Social Influence Processes. Drawing heavily from TRA and Diffusion of Innovation (DOI), Venkatesh and Davis (2000) incorporated three social influence processes with TAM2. The psychology-based term social influence refers to situations where others' interest rather than self-interest affects behavior (Izuagbe & Popoola, 2017).

Subjective Norm. Venkatesh and Davis (2000) cited the TRA when defining subjective norm as situations where people choose a behavior they believe would be viewed as favorable by one or more important people. Izuagbe and Popoola (2017) referred to subjective norm as the perception of social pressure originating from other

individuals considered necessary. In TAM2, subjective norm can influence PU and *intention to use* when other people influence a user's decision to adopt the technology (Marangunić & Granić, 2015). Whether subjective norm will influence PU or lead straight to intent to use depends on a moderating variable, Venkatesh and Davis (2000) called voluntariness.

Voluntariness. The mixed findings surrounding subjective norm in earlier TAM studies were later expounded on in TAM2 once the effects of voluntariness were understood (Asare et al., 2016; Venkatesh & Davis, 2000). With technology adoption, subjective norm can manifest in the form of simple compliance, which leads directly to intention to use, bypassing both PU and PEOU, in situations where adoption is perceived to be mandatory (Venkatesh & Davis, 2000). Recent technology adoption researchers often report that participation was voluntary, implying subjective norm should only influence PU instead of intent (Buijs & Spruit, 2017), which is a form of social compulsion rather than social compliance (Izuagbe & Popoola, 2017). Potential users may also feel compelled to use a piece of technology when image is involved.

Image. Venkatesh and Davis (2000) referenced the DOI theory when explaining how the social element of image would fit in TAM2. Subjective norm can positively influence image when a person believes using an information system will lead to an elevated social status within the group (Izuagbe & Popoola, 2017; Venkatesh & Davis, 2000). Increasing ones standing within a group at work translates into peer-support and the potential for increased power and influence, which inevitably leads to greater productivity and improved job performance (Venkatesh & Davis, 2000). In this way, subjective norm positively impacts image, which indirectly leads to an elevation in PU.

Unlike the direct influence subjective norm has on PU and intention to use, the power of image does not weaken over time as the user gains experience with the system (Venkatesh & Davis, 2000).

Experience. In TAM2, Venkatesh and Davis consistently show how individuals rely less on social information when making PU and intention to use decisions once direct experience with a system has been obtained (Izuagbe & Popoola, 2017). Experience with the system will determine ongoing use, even though subjective norm demonstrates a strong influence over PU and intention to use before implementation and during early system use (Venkatesh & Davis, 2000). Conversely, if a favorable group norm supports continued system use, experience does not negate the indirect influence image has on PU (Venkatesh & Davis, 2000).

Cognitive Instrumental Processes. In addition to social considerations, Venkatesh and Davis (2000) theorized that perceptions of usefulness are also formed in part when people cognitively compare system capabilities to what is needed to get the job done. In TAM2, PEOU is a cognitive instrumental process that directly influences PU because systems that take less effort to increase job performance (Venkatesh & Davis, 2000). The three new cognitive constructs added to TAM2 included job relevance, output quality, and result demonstrability.

Job Relevance. System users form an image of job relevance when considering the list of job-relevant tasks a system can perform (Venkatesh & Davis, 2000). Marangunić and Granić (2015) described job relevance as “the degree to which technology was applicable” (p. 86). Venkatesh and Davis (2000) further explained how job relevance is an element of a compatibility test user's cognitively conduct. Systems are

not considered for future adoption if a minimum set of job-relevant tasks are missing. The quality of tasks performed will also be evaluated for systems that pass a person's self-defined compatibility test.

Output Quality. The quality of tasks performed by a system was defined by Venkatesh and Davis (2000) as output quality. Izuagbe and Popoola (2017) pointed out that the degree to which the system outputs are error-free is a vital aspect of output quality. When multiple systems have passed the job relevance compatibility test, users conduct a profitability test to select the system producing the highest output quality (Venkatesh & Davis, 2000). Relevant job-related tasks and quality of output are essential system attributes, yet adoption can still fail if actual system use does not lead to relevant gains.

Result Demonstrability. Venkatesh and Davis (2000) refer to the positive and tangible results of system use as result demonstrability. Users who cannot cognitively attribute positive gains to system use may choose not to adopt the system (Izuagbe & Popoola, 2017). Venkatesh and Davis (2000) confirmed in their seminal study of TAM2 that positive results of system usage that are easily discernable will positively impact PU, while positive results that are obscure to the user are unlikely to increase the perception of usefulness. Unlike the initial social influences that become less relevant as users gain direct experience with a new system, cognitive instrumental processes continue to influence PU over time (Venkatesh & Davis, 2000).

TAM2 Limitations

Despite the dominant presence and well-defined strengths of the various iterations of TAM found in the literature, distinct limitations of the framework have been explored

(Faqih & Jaradat, 2015; Hwang et al., 2016; Izuagbe & Popoola, 2017; Rondan-Cataluña et al., 2015). Multiple studies have reported mixed results validating specific antecedents to PU. Some researchers attempting to validate result demonstrability as a determinant of PU have been largely unsuccessful (Faqih & Jaradat, 2015; Izuagbe & Popoola, 2017). In addition to result demonstrability, Faqih and Jaradat (2015) were unable to empirically demonstrate a significant impact of subjective norm on PU while investigating mobile commerce technology's adoption.

Rondan-Cataluña et al. (2015) attempted to empirically test all central technology acceptance models by investigating mobile Internet users in Chile. The results of the Rondan-Cataluña et al. (2015) study indicated that TAM2 did not outperform TAM in explaining the acceptance of mobile Internet use. The accuracy of behavioral intent to use dropped more than 34% when the researchers dropped attitude from the model (Rondan-Cataluña et al., 2015). The study results also indicated that with all of the technology acceptance models tested, nonlinear relationships produced better explanatory results than the traditional linear approach.

A final limitation that has been reported by multiple authors seeking to increase user adoption is the lack of practical and actionable guidance in TAM and TAM2 (Faqih & Jaradat, 2015; Hwang et al., 2016). Even though technology adoption models such as TAM2 can provide insight into user intentions and behaviors, practitioners need design guidance and implementation strategies (Hwang et al., 2016). Faqih and Jaradat (2015) noted that earlier TAM frameworks did not provide advice for creating effective interventions or other mechanisms that foster positive user perceptions and behaviors toward adopting new technology. Preadoption variables that could influence user

perceptions or inform the implementation process are also missing from TAM (Hwang et al., 2016). Additional constructs were added to TAM3 to overcome the reported limitations in earlier TAM models and provide more actionable and practical guidelines for IT practitioners (Faqih & Jaradat, 2015; Hwang et al., 2016).

Modern TAM2 Studies

Early in the literature search, it became apparent that a wide range of scholarly studies was describing TAM2 as an accessible and valuable technology adoption model. Buijs and Spruit (2017) successfully used TAM2 to investigate the usefulness of implementing a social search as a single point of access to an organization's information. The exploratory case study results indicated that 100% of the participants demonstrated a positive attitude towards the new technology and found the prototype social search highly useful (Buijs & Spruit, 2017). In another exploratory case study, Justus (2017) reported that TAM2 was successfully used to highlight specific conditions and attitudes demonstrated by faculty members in higher education who adopt emerging technology. Qualitative case study and TAM2 appear to be well suited for investigating modern technology adoption. Similarly, in my multiple-case study I incorporated TAM2 as a lens while researching strategies for implementing M&S technology.

Healthcare, mobile technology, and hospitality are additional sectors where researchers commonly rely on TAM. Multiple researchers have tested the validity of using TAM to predict electronic health record adoption from various users' standpoint (Chauhan & Jaiswal, 2017; Razmak & Bélanger, 2018). Other authors have successfully used TAM and TAM2 together while researching adoption and developing strategies related to mobile technology (Ramadan & Aita, 2018; Sanakulov et al., 2018). Likewise,

in the hospitality sector, TAM2 has been used to investigate topics ranging from the advancement of human-robot interactions (Tung & Law, 2017) to the technology adoption of front-line employees (Montargot & Ben Lahouel, 2018). Based on the wide range of modern studies incorporating TAM2 precepts, the model appears to be a valid and relevant conceptual framework for researching technology adoption. Therefore, the model complemented my study, considering the built-in heavy technology adoption elements.

TAM in Military Studies

Researchers have long recognized the applicability of using the various TAM frameworks while conducting investigations that could benefit the military. Hawkins and Gravier (2018) acknowledged the impact PU and PEOU could have on the military adoption of commercial off-the-shelf software and hardware. Likewise, Sadagic et al. (2016) stated that PU and PEOU could significantly impact 3D printing technology adoption. Levy and Green (2009) confirmed the goodness-of-fit of using the extended TAM when researching U.S. Navy combat information systems' acceptance. With studies spanning a wide range of technologies, it appears that TAM is an appropriate framework for investigating technology adoption in the military domain. Additionally, the literature demonstrated that TAM was being used in some areas of military research more prominently.

Two substantial areas where researchers have applied the TAM include education and training. Cigdem and Topcu (2015) found the TAM2 constructs of PU, PEOU, and subjective norm all positively impacted military instructor’s intent to use a Learning Management System (LMS). Other military studies incorporating TAM2 found that PU

displayed a significant influence on students' acceptance of e-assessments (Cigdem & Oncu, 2015), and PEOU has a direct influence over the intent to use web-based testing (Cigdem et al., 2016). When studying the acceptance of new C-130 aircrew training technology, Hathaway and Cross (2016) found that 83% of the participants found PU to be instrumental, while 94% agreed that PEOU was a determinant. Military education and training is one area of research where practitioners are successfully using TAM. Military application of M&S technology is another notable area of research commonly found to include TAM2 constructs.

TAM in M&S Studies

The academic community, including military researchers, have applied TAM to modeling and simulation research. While many researchers use TAM2 to predict the overall probability of user acceptance (Stütz et al., 2017), other researchers have found that social influences play a significant role in the adoption of M&S technology (Rauschnabel & Ro, 2016; Yuniarto et al., 2018). The TAM has been applied in military M&S studies designed to evaluate (a) decision making (Mao et al., 2017), (b) surgical cricothyroidotomy (Proctor, & Campbell-Wynn, 2014), and (c) aviation maintenance training systems (Wang et al., 2016). Augmented reality studies that incorporate 3D M&S technology often incorporate various TAM components (Chung et al., 2015; Rese et al., 2017). The research clearly shows the TAM framework included in a wide range of M&S studies. Using TAM to investigate key elements that may directly impact M&S integration would be a strategic implementation of the conceptual framework.

Analysis of Supporting Theories

Before selecting a conceptual model for my doctoral study, I evaluated four technology acceptance models for possible inclusion. Even though the original TAM has been a proven model for predicting technology adoption, TAM2 is up to 24% more effective when explaining usage intent (Izuagbe & Popoola, 2017). Once researchers replaced the attitude construct with intention to use (Asampana et al., 2017; Marangunić & Granić, 2015), the construct was never included in future TAM expansions, which indicates the importance of investigating usage intention while researching technology adoption. When developing TAM3, Venkatesh and Bala did include intention to use and all of the PU antecedents found in TAM2 (as cited in Rondan-Cataluña et al., 2015, p. 792). The primary purpose of TAM3 was to expand PEOU with four additional determinants considered to be anchors and two additional determinants categorized as adjustments (Rondan-Cataluña et al., 2015).

The four PEOU anchors include (a) computer self-efficacy, (b) computer anxiety, (c) computer playfulness, and (d) perceptions of external control (Faqih & Jaradat, 2015; Rondan-Cataluña et al., 2015). The two PEOU adjustments theorized to have a stronger influence once users obtained experience with a new system included perceived enjoyment and objective usability (Faqih & Jaradat, 2015; Rondan-Cataluña et al., 2015). Even though TAM3 is an extension of previous TAM versions, the model has suffered from scholarly researchers' lack of use (Faqih & Jaradat, 2015). Other authors have criticized TAM3 for being overly complex, with the mediating constructs reaching 17 in total (Rauschnabel & Ro, 2016). Excessive TAM3 antecedents led Faqih and Jaradat (2015) to acknowledge that postimplementation variables such as perceived enjoyment

and objective usability would need to be deleted by researchers before the model was suitable for early adoption studies.

Unified Theory of Acceptance and Use of Technology (UTAUT). The final model considered was the UTAUT. Eight prominent technology adoption models to include TAM were synthesized by the developers to create UTAUT (Rondan-Cataluña et al., 2015; Yaseen & El Qirem, 2018). The four core constructs of UTAUT include (a) performance expectancy, (b) effort expectancy, (c) social influence, and (c) facilitating conditions (Rauschnabel & Ro, 2016; Rondan-Cataluña et al., 2015; Yaseen & El Qirem, 2018). Like TAM, performance expectancy equates to usefulness, while effort expectancy mimics perceived ease of use (Rauschnabel & Ro, 2016; Spreer & Rauschnabel, 2016). While the original longitudinal study did suggest that UTAUT could be used to explain approximately 70% of the variance in behavioral intent (Yaseen & El Qirem, 2018), Birch and Irvine could only explain 27% of the variance in behavioral intent in their later study that utilized UTAUT (as cited in Ifenthaler & Schweinbenz, 2016). Other factors were taken into consideration, as well. For instance, both TAM2 and UTAUT are used to study technology implementation inside organizations (Rondan-Cataluña et al., 2015). While the original authors attempted to retain a parsimonious structure with UTAUT, the model is still widely considered less parsimonious than TAM2 (Buijs & Spruit, 2017). Ultimately, UTAUT utilizes 41 independent variables and eight dependent variables, making the model considerably more complex to use (Buijs & Spruit, 2017; James et al., 2015).

Analysis of Contrasting Theories

While the popularity of TAM, TAM2, TAM3, and UTAUT are evident by the tens of thousands of scholarly articles citing the models, some scholars believe Information System (IS) researchers need to consider the development or adoption of other frameworks (Shachak et al., 2019). According to Shachak et al. (2019), the contributions TAM and UTAUT can make to the body of knowledge have plateaued, and continued widespread use may pigeonhole IS research. Therefore, contrasting theories should be examined by scholars for goodness of fit.

Disruptive Innovation Theory. Disruptive innovation theory is a conceptual framework that has significantly impacted the business world (Nagy et al., 2016; Vecchiato, 2017). The theory's core tenants suggest that consumers stop using a mainstream product and adopt a disruptive innovation or technology because of new features or a significantly lower price tag (Nagy et al., 2016; Reinhardt & Gurtner, 2018). According to McHenry (2016), incumbents are often complacent and ignore noncustomers and new technologies until it is too late. Eventually, the disruptive technology quality improves to the point where the incumbent loses customers and market share (McHenry, 2016; Vecchiato, 2017). Despite the popularity of the disruptive innovation theory in the business sector, the impact of disruptive technology is still not fully understood (Li et al., 2018; Vecchiato, 2017). Additional limitations of the model include a heavy focus on marketing and managerial competence (Vecchiato, 2017) and vague and varying definitions of disruptive innovation (Li et al., 2018). Ultimately the disruptive innovation theory was designed to monitor the market, predict product consumption, and help incumbents stay relevant and on top of the market share. The

theory does not appear to be an appropriate lens for a study designed to investigate M&S implementations in a niche sector, where tools are developed or customized in-house.

Resource-Based View (RBV). The RBV is a theoretical and conceptual framework that stipulates an organization's competitive advantage due to the firm's ability to obtain and control resources (Costa et al., 2018; Jensen et al., 2016; Popli et al., 2017; Wang et al., 2018). According to Barney, resources can be tangible or intangible and encompass financial, physical, human, and organizational resources (as cited in Costa et al., 2018; Wang et al., 2018). RBV is an ideal framework for examining a company's performance (Cruz & Haugan, 2019; Yu et al., 2018). Even though resources include computer hardware and software, and the RBV has been used to investigate open-source software projects (Wang et al., 2018), the framework is primarily a business management theory (Cruz & Haugan, 2019). Furthermore, a common critique of RBV is the difficulty in measuring technological capabilities (Fung, 2017; Sayeed & Onetti, 2018). While the framework may be appropriate for investigating an M&S firm's competitive advantage in the marketplace, the framework will not help researchers explore technology's implementation inside an organization. Conceptual frameworks that focus on marketing and consumer trends (disruptive innovation theory) and company resources management (RBV) were not well suited for my investigation into M&S implementation strategies.

Analysis of Potential Themes and Phenomena

The following sections address the most relevant M&S themes found in the literature that have a well-established impact on the implementation of M&S technology. Clear and concise definitions for models and simulations are needed to establish the research's context and identified literary themes. The DoD defines a model as "a physical,

mathematical, or otherwise logical representation of a system, entity, phenomenon, or process," and simulation as "a method for implementing a model over time" (DoD, 2018, p 10). Therefore, it stands to reason that in the discipline of M&S, the model must come before the simulation. Before developing a model or simulation, the team must define the requirements in a conceptual model.

Conceptual Modeling

The practice of developing different types of conceptual models is seen widely across all STEM fields. In M&S, a conceptual model is a description of the intended model or simulation that includes the assumptions and simplifications, data inputs and outputs, as well as other content needed to describe the model (Chanpuypetch & Kritchanchai, 2018; DoD MSE, 2020; Mensah et al., 2017; Seo et al., 2017). Before a conceptual model can be abstracted, the modeler must thoroughly understand the real-world system (Furian et al., 2018; McHaney et al., 2018; Proudlove et al., 2017; Zhou & Herath, 2017). Considerable thought and planning should go into the creation of a conceptual model. If not, the entire M&S project could face challenges.

Importance. The impact conceptual modeling has on an M&S project is evident in the literature. Many authors report conceptual modeling as a critical first step when developing models (Argent et al., 2016; Fan et al., 2016; Furian et al., 2018; Nalchigar & Yu, 2018). Not only is conceptual modeling described as one of the most critical M&S steps (Arbez & Birta, 2016; Furian et al., 2018; Powell & Mustafee, 2017), it is also evident that when executed improperly, the quality of the final model will be negatively impacted (Fan et al., 2016). Proper M&S implementation requires the development of an accurate conceptual model at the beginning of the project. Furthermore, scholars in

academic studies explore the importance of effectively developing conceptual models that traverse various research domains.

Diverse Sectors. The breadth of scholarly articles that address M&S conceptual modeling efforts spans diverse sectors. The complexity of M&S projects in the supply chain management sector requires structured and well-designed conceptual models (Mensah et al., 2017; Pedram et al., 2017; Pinho et al., 2016; Takeda Berger et al., 2018). The design of cardiopulmonary-related conceptual models often necessitates extensive research or input from multiple subject matter experts (Hoogendoorn et al., 2019; McHaney et al., 2018; Thackray & Roberts, 2017). Even a research topic as novel as simulating water will produce many scholarly articles describing the various conceptual models required for project success (Nguyen et al., 2018; Peters, 2016; Yilmaz Turali & Simsek, 2017; Zhou & Herath, 2017). Conceptual modeling will undoubtedly impact M&S implementation in military organizations, considering the diversity of sectors submitting scholarly articles on the topic. How practitioners gather data and feedback during the conceptual modeling process will also impact the outcome.

Stakeholder Engagement. Even though there is no universally accepted standard for creating a conceptual model (Argent et al., 2016), each method typically includes some stakeholder participation. M&S teams use collaborative conceptual modeling to achieve a common understanding of the intended model among stakeholders (Nicolaescu et al., 2018; Oppl, 2016; Seo et al., 2017). While participatory conceptual modeling is collaborative, the stakeholder pool is larger and more inclusive of diverse participants (Argent et al., 2016; Kotir et al., 2017). Regardless of the approach used to guide the conceptual modeling process, the literature clearly shows that higher stakeholder

engagement levels are a best practice (Argent et al., 2016; Fulton et al., 2015; Furian et al., 2018; Kotir et al., 2017). The same best practice should apply to military M&S projects.

Method-specific. In military organizations, Discrete Event Simulation (DES), Agent-Based Simulation (ABS), and System Dynamics (DS) are the most commonly used M&S methodologies (Jnitova et al., 2017). Moreover, the literature supports this precept with conceptual modeling articles that are method-specific.

DES. Historically modelers have taken a standard approach to create DES conceptual models, but more recent studies indicate modelers are exploring more diverse solutions. While most DES conceptual models have focused on constructing queue-based paradigms, a more modern approach utilizes Hierarchical Control Conceptual Modeling (Furian et al., 2015; Golzarpoor et al., 2017; Pongjetanapong et al., 2018). Modeling paradigms used to create DES conceptual models include (a) activity-based diagrams (Arbez & Birta, 2016; Scheidegger et al., 2018), (b) business process modeling (Proudlove et al., 2017; Scheidegger et al., 2018), and (c) domain-specific solutions needed for complex systems (Hoogendoorn et al., 2019; Monks et al., 2017). Whether a traditional queue-based approach expressed in a business process model or a more modern technique is used, present-day modelers have multiple examples to choose from. Insight into how military organizations are developing DES conceptual models would add to the M&S body of knowledge.

ABS. Conceptual models designed for ABS efforts must illustrate the interactions of individual agents within an environment. The Unified Modeling Language (UML) is a modeling language suitable for describing various steps and actions an entity could

perform while interacting with a system or attempting to achieve an objective (Angelopoulou et al., 2015). The literature contains an abundance of highly detailed UML-based conceptual models created for ABS studies (Angelopoulou et al., 2015; Jumadi et al., 2017; Verhoog et al., 2016). A UML alternative for creating ABS conceptual models is the Business Process Modeling Notation (BPMN) language (Scheidegger et al., 2018; Tello-Leal et al., 2016). Based on my literature search, UML appears to be the preferred approach for creating ABS conceptual models. In the literature, it is not clear whether the military utilizes UML for conceptual modeling as often as the public sector.

SD. Conceptual modeling of SD projects can require a combination of diagrams. At a minimum, an SD model's conceptualization will create a Causal Loop Diagram (CLD; Hidayatno et al., 2019; Kotir et al., 2017; Tegegne et al., 2018). The CLD is then used to create a stock and flow diagram (Gunadi, 2015). Even though CLD and stock and flow diagrams are considered SD conceptual modeling tools, the stock and flow diagram is often considered the core of SD modeling and simulations (Alefari et al., 2018; Fayoumi & Loucopoulos, 2016). Even though modelers are using multiple tools and modeling languages to create SD conceptual models (Scheidegger et al., 2018), using a CLD to create a stock and flow diagram appears to be a conceptual modeling best practice for SD projects. Familiarity with multiple SD conceptual modeling paradigms should positively impact the implementation of M&S technology.

Modeling Methods

A customized conceptual model's characteristics, including the available data, problem details, research goals, and the system's nature to be modeled, will determine

which modeling methods are needed (Scheidegger et al., 2018). According to the literature, the most commonly used M&S methods include DES, ABS, and SD (Alice et al., 2018; Brailsford et al., 2018; Goh & Ali, 2016; Jnitova et al., 2017; Scheidegger et al., 2018). To effectively pair a conceptual model with one or more modeling methods, researchers need to understand the general characteristics, strengths, and weaknesses of the top three methodologies (Scheidegger et al., 2018).

DES. Even though DES can model various process-driven systems, the method is most applicable to manufacturing systems (Barbosa & Azevedo, 2017; Brailsford et al., 2018; Scheidegger et al., 2018). Two additional areas where DES-based M&S is often applied include construction (Golzarpoor et al., 2017; Longman & Miles, 2019) and logistics (Lang et al., 2017; Smith & Srinivas, 2019). Modelers use the DES method to model systems that involve entities moving through a series of steps or queues at discrete points in time (Barbosa & Azevedo, 2017; Goh & Ali, 2016; Jnitova et al., 2017; Scheidegger et al., 2018). Flexibility in that modelers can code nearly any process into a model is a strength of DES (Jnitova et al., 2017). However, entities and resources in a DES model cannot interact adaptively, as can be done with other M&S methods (Goh & Ali, 2016).

Supporting Software. Another strength of DES is the abundance of supported software applications and tools used to implement the modeling method (Scheidegger et al., 2018). A few of the more popular DES software solutions include (a) Simio, (b) ProModel, (c) Arena, (d) AnyLogic, (e) FlexSim, and (f) Simul8 (Amaran et al., 2016; Anagnostou & Taylor, 2017; Scheidegger et al., 2018; Vile et al., 2017). While the previous list of DES applications is nowhere near exhaustive, each of the tools is

considered by expert modelers to be a popular and powerful graphical animation tool for DES M&S (Scheidegger et al., 2018).

ABS. Agent-based modeling and simulation use a bottom-up perspective (Abar, Theodoropoulos, et al., 2017; Alice et al., 2018; Barbosa & Azevedo, 2017; Goh & Ali, 2016; Mahjoubpour et al., 2018). The M&S method is used in various fields, including economics, biology, sociology, social sciences, and multiple STEM disciplines (Abar et al., 2017; Mahjoubpour et al., 2018; Williams, 2018). With ABS, individual autonomous agents interact in a shared environment by following sets of predefined agent rules (Abar et al., 2017; Barbosa & Azevedo, 2017; Goh & Ali, 2016; Mahjoubpour et al., 2018; Williams, 2018). Through the agents' interactions, widespread patterns emerge, indicating previously unknown complex behaviors of the simulated systems (Abar et al., 2017; Barbosa & Azevedo, 2017; Goh & Ali, 2016; Mahjoubpour et al., 2018). Another benefit is that by using existing ABS applications, users can quickly produce results in functioning models and simulations (Williams, 2018). Conversely, the same ease of use can lead to inexperienced modelers neglecting to follow solid conceptual modeling, verification, and validation techniques, which can tarnish ABS models' credibility (Williams, 2018).

Supporting Software. The number of available ABS software tools and applications is limited compared to DES, but several useful products have been developed (Brailsford et al., 2018; Scheidegger et al., 2018). Commonly used ABS applications include (a) NetLogo, (b) Ascape, (c) RePast, (d) AnyLogic, (e) StarLogo, and (f) ExtendSim (Abar et al., 2017; Scheidegger et al., 2018). According to Abar et al.

(2017), ABS applications help researchers demonstrate how microlevel agents can influence macroscopic system behaviors.

SD. System dynamics uses a top-down approach to modeling and simulation (Goh & Ali, 2016; Liang et al., 2018; Scheidegger et al., 2018; Yu & Fang, 2017). With SD, modelers create a higher system view using stocks, flows, and feedback loops (Goh & Ali, 2016; Jnitova et al., 2017; Scheidegger et al., 2018). Additionally, system dynamics models require differential equations (Goh & Ali, 2016; Rad & Rowzan, 2018; Scheidegger et al., 2018). System dynamics is considered a system thinking methodology that is well suited for complex systems (Barbosa & Azevedo, 2017; Scheidegger et al., 2018; Yu & Fang, 2017). While SD is effective at modeling dynamic system changes over time (Barbosa & Azevedo, 2017; Golroudbary et al., 2019), the method is not suitable for low-level mapping elements (Scheidegger et al., 2018) or discrete events (Barbosa & Azevedo, 2017). In addition to supply chains, software engineering, stock markets, economics, ecology, innovation, and workforce management (Barbosa & Azevedo, 2017; Scheidegger et al., 2018), the SD modeling methodology is well suited for policy development (Brailsford et al., 2018; Liang et al., 2018).

Supporting Software. As with DES, many user-friendly SD software packages have been developed (Brailsford et al., 2018). Of the many SD tools available (a) AnyLogic, (b) PowerSim, (c) Vensim, and (d) Stella are the most popular (Neuwirth, 2017; Scheidegger et al., 2018; Stadnicka & Litwin, 2017). Despite the availability of multiple user-friendly SD modeling and simulation packages, SD modelers typically require considerable skill and mathematics knowledge (Scheidegger et al., 2018).

Hybrid. Hybrid modeling and simulation involve the combination of two or more of the core M&S methods, which are DES, ABS, and SD (Alice et al., 2018; Barbosa & Azevedo, 2017; Barbosa & Azevedo, 2018; Brailsford et al., 2018). The ever-increasing complexity of modeled systems has led to the heightened use of hybrid M&S methods (Goh & Ali, 2016; Jnitova et al., 2017; Morgan et al., 2017; Scheidegger et al., 2018). Although combing methods allows modelers to combine strengths (Alice et al., 2018; Jnitova et al., 2017) while simultaneously avoiding the shortfalls of using a single method (Morgan et al., 2017; Rad & Rowzan, 2018), a best practice is only to use a hybrid approach when two or more methods are equally required (Barbosa & Azevedo, 2017; Morgan et al., 2017). Depending on the specifics of the M&S project, implementing a hybrid methodology can be advantageous, especially when the real-world system is exceptionally complex.

Hybrid methods come with specific challenges as well. Successful hybrid implementation requires extensive knowledge of multiple methods, flexibility, and higher practitioner skillsets (Barbosa & Azevedo, 2017). Despite the importance of conceptual modeling and the availability of method-specific conceptual modeling paradigms, the literature clearly shows a lack of hybrid conceptual models (Brailsford et al., 2018). Implementing a hybrid method using a single M&S tool can be problematic as well. Whereas some modelers can successfully use a single M&S application that was designed for a specific method while incorporating principals or libraries from a second modeling method (Barbosa & Azevedo, 2017), other researchers compare this process to forcing a "square peg into a round hole" (Brailsford et al., 2018, p. 2).

Last, verification and validation of hybrid models involves significant challenges, evidenced by the lack of V&V results published in hybrid M&S studies (Brailsford et al., 2018). Despite the apparent benefits of using hybrid methods for specific M&S scenarios, considerable challenges must be considered and overcome.

Verification & Validation

A vital step in the implementation of M&S technology documented in the literature is verification and validation (V&V). The DoD defines verification as the process used to check whether a model or simulation has been accurately implemented according to the original conceptual description and specifications (DoD, 2018). Likewise, validation refers to the process used to determine whether a model or simulation accurately depicts the real world as intended (DoD, 2018). Other researchers have described verification as *solving the equations right* and validation as *solving the right equations* (Dadzis et al., 2017; Hicks et al., 2015). No matter which definitions authors use, models and simulations that have not passed V&V cannot be trusted. Understanding the essential nature of V&V is necessary for researchers investigating M&S.

Throughout the studies dedicated to M&S V&V, the authors repeatedly stressed the importance of consistently and correctly conducting these processes. Without verification and validation, models and simulations are useless. Therefore, practitioners should treat V&V as a required project (Kendall et al., 2017). According to Hicks et al. (2015), V&V is so vital that when neglected, researchers have trouble obtaining funding, demonstrating utility, and publishing papers, which are all plaguing the biological systems M&S field. Before models and simulations can be trusted and fully integrated

into practice, managers must provide successful V&V results (Alessandrini et al., 2015; Barajas et al., 2016; Chen et al., 2015; Hicks et al., 2015; Kendall et al., 2017). The impact V&V has on the implementation of M&S is evident. Understanding when to conduct verification and when to conduct validation, and which step is more critical to a specific study is also an essential consideration for M&S implementation.

All through the literature, separate components of V&V are presented differently, with specific aspects presented as more challenging than others. The processes attributed to verification must always happen before the validation methods are employed (Hicks et al., 2015; Kendall et al., 2017). Very few M&S studies are similar to the research conducted by Hein et al. (2018), focusing solely on verification. Even though the M&S team should conduct multiple forms of verification throughout the project (Kendall et al., 2017), the overall process is comparable to standard software unit-testing (Hicks et al., 2015) or mathematical analysis (Popoola & Sinanović, 2018), which leads to the acknowledgment that validation is the real challenge and focus of V&V (Chen et al., 2015; Hicks et al., 2015). If *solving the equation right* encapsulates verification through math-checking and unit-testing, the question then becomes how do researchers demonstrate that they selected the right equation for the M&S project. The literature indicates that M&S validation most often requires experimentation to demonstrate the solution accurately imitates the real-world as intended.

A few standardized M&S validation frameworks exist, but in most instances, it is the modeler's responsibility to justify and explain the validation process developed to demonstrate the usefulness of the model. The validation of models and simulations dealing with theorized electrical conduction may require experimental data captured

during the testing of power converters (Beg et al., 2017), new silicon-based semiconductors (Anwar et al., 2017), or cryogenically cooled superconducting magnets (Xu et al., 2016). Quasistatic testing, Split Hopkins bar testing, and flyer plate impact testing were all used to validate Johnson-Cook based simulations of a laser peen process (Langer et al., 2015). In another study, researchers developed an M&S solution to test a new type of double rotor switched reluctance machine (DRSRM) found in hybrid electric vehicles (Yang et al., 2016). Before they could validate the model and simulations, they first had to manufacture and test a DRSRM prototype (Yang et al., 2016). In most instances, custom-designed experimental tests must be designed and used to validate M&S solutions. When models and simulations can impact human life, experimental validation is even more critical.

Confidence in the validation of M&S solutions that can be used to save human lives or jeopardize human life, if improperly implemented, requires extensive testing. Huang et al. (2017) fabricated a full-scale iron helicopter to validate an M&S solution to develop lightning protection experimentally. The validation of a critical M&S solution used to develop a new remote maintenance process for the International Fusion Materials Irradiation Facility (IFMIF) in Italy required testing a full-scale prototype of an IFMIF target assembly (Micciche et al., 2017). For the experimental validation of a simulated radiation detector system, the researchers implemented fluorescence and synchrotron radiation tests, and X-ray tube spectra, and beta decay tests, in addition to comparison validation using another well-established TCAD simulation solution (Krapohl et al., 2016). In each of these instances, scientists developed a novel validation test for a

specific M&S implementation. In other situations, researchers present new M&S V&V methodologies that can be used broadly by other researchers in the same field of study.

The creation of commonly used V&V standards, such as the IEEE standard 1597 designed to validate computational electromagnetics models and simulations (Park et al., 2017), are rare but the objective of multiple M&S studies. In the medical field, the widespread use of M&S tools to diagnose and treat cardiac conditions is limited because of a lack of reliable V&V techniques (Alessandrini et al., 2015). In response, multiple researchers are publishing V&V methodologies designed to experimentally test cardiac-related M&S solutions (Alessandrini et al., 2015; Gindre et al., 2017; Larsson et al., 2017). Similarly, Flintoft et al. (2017) published a V&V test-suite used by researchers conducting complex electromagnetic compatibility (EMC) M&S projects. Barajas et al. (2016) published a V&V framework for modelers working with serious game technology, acknowledging the impact properly implemented V&V methods have on adoption rates. With so many studies publishing reusable V&V frameworks, it is evident that widespread M&S adoption depends on reliable V&V results. Unfortunately, some fields utilizing M&S technology do not commonly publish papers covering the implemented V&V methodologies.

The M&S research community needs access to gold-standard validation datasets produced from high-fidelity tests (Hicks et al., 2015). Kendall et al. (2017) published a detailed paper for the DoD on the V&V of the Computational Research and Engineering Acquisition Tools and Environments (CREATE) program. The V&V of the Infantry Warrior Simulation (IWARS) required Eaton et al. (2014) to use statistical analysis and real-world data collected from Vietnam, Iraq, and Afghanistan combat veterans. While

Eaton et al. (2014) acknowledged the primary motivation for publishing the research was to help other analysts create more accurate models, most military-related M&S papers are not focused on sharing V&V techniques and datasets. Gathering strategies military organizations have used to conduct V&V of M&S technology would undoubtedly address a significant gap in the M&S body of knowledge.

Qualitative Interviews

The qualitative design used for this research was a multiple-case study. Qualitative case studies often incorporate semistructured interviews as the primary data collection method (Hoeber & Shaw, 2017). While it is common for a qualitative study to include a single interview method, it is becoming more common for researchers to conduct multiple types of interviews in a single study (Heath et al., 2018). Modern qualitative researchers can employ (a) face-to-face, (b) synchronous online, (c) email, and (d) telephone interviews (Heath et al., 2018). Even though in-person face-to-face interviews are considered the gold standard and face-to-face online a close second (Heath et al., 2018), email and phone interviews also produce insight-rich data (Hershberger & Kavanaugh, 2017). Although the benefits and shortfalls of different interview methods are up for debate, researchers tend to agree that by offering more than one interview option, participation is likely to increase (Heath et al., 2018; Hershberger & Kavanaugh, 2017). Considering the benefits of modern qualitative interview methods, in-person, face-to-face, and face-to-face online interviews should be sought first, with phone and email offered as alternatives with the intent of increasing participation. Incorporating multiple interview techniques was a benefit to my study, which targeted IT project managers working for military organizations across the eastern region of the United States.

Additional strategies for conducting effective qualitative interviews are present in the literature. Data gathered using more than one collection technique are more likely to produce equivalent results when a well-constructed interview guide is applied consistently (Hershberger & Kavanaugh, 2017) and when the participants are technologically savvy (Heath et al., 2018; Rosenthal, 2016). If investigators are using a conceptual framework to inform the overall study, the investigators should consult the same conceptual framework when developing the interview guide and questions (Martin et al., 2019; Moreau & Eady, 2019; Shorey et al., 2018). In-depth interview guides should include multiple open-ended main interview questions, with additional follow-up probes (Goodell et al., 2016; Martin et al., 2019; Rosenthal, 2016; Shorey et al., 2018). Researchers who use a conceptual framework to inform an interview guide that includes open-ended questions and follow-up probes will be better prepared to conduct qualitative interviews. Researchers who conduct multiple types of interviews with technologically savvy IT practitioners should produce equivalent results across the interview types while consistently using an interview guide.

M&S Multiple-Case Studies

The academic body of knowledge contains a multitude of qualitative case study research. Familiarity with modern multiple-case studies designed to conduct M&S research provided valuable insight into my study. As with other multiple-case studies, the M&S researchers chose the design because of a need for an in-depth investigation of the primary research question (Bokrantz et al., 2017; Issa Mattos et al., 2019; Jolak et al., 2018; Liebel et al., 2018). Scientists consider multiple-case studies to be more robust than single case studies and consider the findings stronger (Jolak et al., 2018; Rodič, 2017). In

addition to incorporating data triangulation (Bokrantz et al., 2017; Issa Mattos et al., 2019; Liebel et al., 2018) for improved validity, multiple-case studies enable cross-case data analysis (Bokrantz et al., 2017; Jolak et al., 2018). Investigators who conduct modern M&S studies by incorporating a multiple-case study design employ a valid and robust qualitative investigation method. Additionally, researchers can use data triangulation and cross-case analysis to help uncover M&S implementation strategies used by military organizations.

An analysis of the available M&S multiple-case studies provided additional insight into modern qualitative interviewing best practices. As was seen in the larger body of knowledge related to multiple-case studies, semistructured interviews were a primary data collection method (Bokrantz et al., 2017; Heikkinen et al., 2017; Issa Mattos et al., 2019; Liebel et al., 2018). Researchers who use a multiple-case study design to investigate M&S often use an interview guide (Bokrantz et al., 2017; Issa Mattos et al., 2019; Liebel et al., 2018). The least number of cases used was two (Liebel et al., 2018), while the largest number of reported cases was six (Issa Mattos et al., 2019). The number of interviews conducted across the literature ranged from nine (Heikkinen et al., 2017) to 15 (Liebel et al., 2018), with researchers determining the final number by following standard saturation criteria (Issa Mattos et al., 2019). Well-informed modeling and simulation researchers conducting multiple-case studies should be prepared to conduct semistructured interviews following an interview guide while attending basic saturation rules. Fundamentally, the widely acknowledged benefits of using a multiple-case study design are well suited for M&S research.

Relationship to Previous Research

The purpose of my study was to gather strategies some IT project managers supporting U.S. military organizations use to implement modern M&S technology. Academics have conducted previous studies to gather best practices and strategies for implementing M&S technology in the healthcare sector (see Table 1). Yet, as of this date, it appears no scholars have published studies of this scope on military M&S. While M&S studies centered on healthcare could be used to inform military implementations, Tako and Robinson (2015) found that health modeling and simulations are quite different compared to the military and other sectors.

Table 1

Previous Healthcare Studies with Strategies for M&S Implementation

Author/Date	Title	Scholarly
Dahabreh et al. (2015)	Guidance for the conduct and reporting of modeling and simulation in the context of health technology assessment	Yes
Marshall et al. (2016)	Good practices in model-informed drug discovery and development: Practice, application, and documentation	Yes
Visser et al. (2017)	Common best practice in modeling and simulation across quantitative disciplines: A comparison of independently emerging proposals	Yes
Cucurull-Sanchez et al. (2019)	Best practices to maximize the use and reuse of quantitative and systems pharmacology models: Recommendations from the United Kingdom Quantitative and Systems Pharmacology Network	Yes

Tangentially related articles designed to investigate the adoption of military M&S training tools are available (Hathaway & Cross, 2016; Mao et al., 2017; Sadagic & Yates, 2015), yet only Hathaway and Cross (2016) published in a scholarly peer-reviewed

journal. These findings support Jnitova et al. (2017) who reviewed the available military M&S literature related to the author's topic and found an abundance of defense publications and conference papers lacking key details needed to understand the research findings. According to Jnitova et al. (2017), peer-reviewed scholarly articles on military M&S were not prevalent. While the literature includes a few scholarly articles on singular aspects of military M&S implementation, such as conceptual modeling (Seo et al., 2017) or verification and validation (Kendall et al., 2017), scholarly studies that investigate the entire breadth of implementation are missing from the body of knowledge.

Transition and Summary

Section 1 provided the foundation of the study. The background, problem, and purpose statements supported the theorized research question, which ultimately framed the available professional and academic literature review. The literature review uncovered several themes relevant to the purpose of the study. First, the conceptual framework was thoroughly investigated to include the foundation, alternate theories, recent advancements, and modern applications in military and M&S studies. The primary review of M&S studies produced three major themes, with two of the major themes including four additional subthemes each. All of the themes provide insight into modern M&S implementations. Lastly, the literature review examined recent studies on qualitative interviewing and multiple-case studies, which were both critical components of my doctoral study. In addition to uncovering pertinent themes, the literature review exposed a complete lack of academic studies designed to extract strategies used to implement M&S technology in military organizations.

Section 2 will expound on key elements of the research plan, which will include human elements (the researcher, participants, ethical research); methodological components (method, design, population, sampling, data collection, and analysis); as well as essential aspects related to the findings (reliability, validity, dependability, creditability, transferability, confirmability, and saturation). Section 3 will present the results (conclusions, implications, and recommendations).

Section 2: The Project

Purpose Statement

The purpose of this qualitative multiple-case study was to explore strategies some IT project managers supporting U.S. military organizations use to implement modern M&S technology. The target population was IT project managers working for three different military organizations in the United States' eastern region, who have successfully implemented modern M&S technology. This study's results could add to the M&S body of knowledge by contributing modern implementation strategies customized to address novel challenges. From a social change perspective, more successful M&S implementations can safeguard human lives in situations where real-world military systems evaluations cannot be executed safely.

Role of the Researcher

In qualitative inquiry, the researcher plays a critical role in the data collection process. In scholarly research, the qualitative researcher is the primary data-gathering instrument (Neuman, 2014). Gathering qualitative data requires a level of flexibility, insight, and responsiveness that only a human can provide (Neuman, 2014). Qualitative researchers should develop and follow an interview protocol to maximize interview consistency (Goodell et al., 2016) and elicit maximum information from the interviewees (Neuman, 2014). The protocol used should provide an outline so that interviews can be conducted similarly (Goodell et al., 2016) while remaining flexible in supporting the data collection process (DeJonckheere & Vaughn, 2019). In my multiple-case study, my role as the primary data-gathering instrument included conducting interviews while following an interview protocol, recording observations, and gathering relevant documentation.

Recording additional qualitative data elements such as context and body language helped develop a deep understanding of the phenomenon (see Patten et al., 2020).

Qualitative data collection requires the researcher to establish close relationships with various research elements (Venselaar & Wamelink, 2017). Qualitative researchers are encouraged to communicate how such relationships were managed (Venselaar & Wamelink, 2017). For over 2 decades, I have supported the DoD as an IT specialist, with the past 10 years spent as an IT project manager leading the development and implementation of various information systems. While I have never managed the development or implementation of M&S technology, the opportunity, resources, and need to manage such projects currently exist and will be required in the future. Since November of 2004, I have lived and worked in the Washington, D.C., metropolitan area. Familiarity with the region and local colleagues and acquaintances supported the data collection process. The participants in my study did not include individuals from my organization or chain of command.

Purposeful researchers should attempt to limit the effects of bias during data collection and analysis (Goodell et al., 2016). Multiple techniques and strategies are available to limit bias. All qualitative researchers should practice reflexivity by continually reflecting on their relationship to the study and their role as the researcher (Venselaar & Wamelink, 2017). Moreover, researchers should seek to capture the participant's beliefs surrounding the phenomenon and avoid personal preconceptions (Goodell et al., 2016; Neuman, 2014). Memoing can be used to create written notes throughout the study, recording one’s personal bias, feelings, and thoughts related to the meaning behind the data (Goodell et al., 2016). Throughout my study, I used reflexivity

and memoing to identify personal bias and preconceptions to protect the participant's beliefs surrounding the phenomenon.

In addition to attending to bias, researchers have an ethical obligation to protect the participants. The Belmont Report, first published in 1979, defines three ethical principles that researchers should use to guide research involving human participants (Kamp et al., 2019; Laage et al., 2017). The first ethical principle is respect for persons (Kamp et al., 2019; Laage et al., 2017). Researchers often address respect for persons by implementing informed consent, where participation is voluntary and can stop at any time (Kamp et al., 2019). The second ethical principle is beneficence (Kamp et al., 2019; Laage et al., 2017). At the core of beneficence is an obligation to protect every participant while maximizing the potential benefits (Kamp et al., 2019). The third ethical principle of the Belmont Report is justice (Kamp et al., 2019; Laage et al., 2017). Justice in research requires a fair process for selecting participants (Kamp et al., 2019), especially when participation could result in a therapeutic benefit (Laage et al., 2017). Throughout my research, I followed the ethical principles established by the Belmont Report.

Participants

In qualitative research, investigators should select participants based on the data needed to inform the research (Amiri et al., 2016). Multiple-case studies require expert informants (Meyer et al., 2019) who are knowledgeable of the research phenomenon and can provide the input and insight needed to ground the research in a real-world context (Zondag et al., 2017). In addition to exploring a contemporary phenomenon in a real-world context, investigators have used multiple-case studies to answer how and why type of questions (Alpi & Evans, 2019; Parjanen & Hyypiä, 2019; Van De Weerd et al., 2016).

Considering the purpose of my qualitative multiple-case study, eligible participants had to be full-time civil service employees who participated in the successful implementation of M&S technology in military organizations. Each participant was knowledgeable of the entire implementation process. Participants were considered experts in their field with at least 7 years of IT experience. Last, the participants had supported M&S implementations for military organizations located on the East Coast of the United States.

One of the biggest challenges in qualitative research that impacts both the data quality and trustworthiness of the findings is gaining access to the participants (Maunganidze, 2019). A qualitative study's successful completion will require experienced participants who can provide meaningful insight into the primary research questions (Maramwidze-Merrison, 2016). Many researchers rely on a "gatekeeper" who can provide or block access to potential participants within an organization (Walther et al., 2017), while other researchers develop strategies to bypass gatekeepers and contact potential participants directly (Maramwidze-Merrison, 2016). Qualitative researchers seeking to identify and gain access to qualified participants should consider using one or more of the following techniques:

- use personal contacts first (Maunganidze, 2019);
- rely on a gatekeeper (Walther et al., 2017);
- conduct an Internet search for qualified participants (Maramwidze-Merrison, 2016);
- review organizational websites and list servers (Maramwidze-Merrison, 2016; Martell & Stevens, 2019);

- search social and professional networks such as Twitter, Facebook, and LinkedIn (Maramwidze-Merrison, 2016);
- send solicitation e-mails (Maramwidze-Merrison, 2016; Maunganidze, 2019);
- recruit additional participants using the snowball technique (Maramwidze-Merrison, 2016; Maunganidze, 2019).

In my multiple-case study, I used my personal and professional contacts to access a purposively selected group of highly skilled IT project managers who meet the eligibility criteria. Both phone calls and invitation emails were used to recruit participants. I had multiple contacts at four or more military organizations that meet the eligibility criteria. When additional contacts were needed to obtain each organization's initial participants, I searched social and professional networks such as Facebook and LinkedIn. Snowball sampling was used to recruit additional participants in each organization until I demonstrated saturation.

Gathering qualitative data through interviews and observations requires establishing close relationships between the researcher and participant (Venselaar & Wamelink, 2017). The objective of establishing relationships is to put the participants at ease and foster trust, ideally before the interviews are held (Maunganidze, 2019). It is most common for researchers to create trusting relationships through repeated interactions with the participants (Maunganidze, 2019). If the researcher has limited opportunities for in-person interactions, the researcher can establish an online relationship of trust by using a combination of (a) email, (b) phone, (c) Twitter, (d) Facebook, and (e) LinkedIn communications (Maramwidze-Merrison, 2016). Ultimately, qualitative researchers should attempt to reduce the metaphorical distance between the

researcher and participants by fostering an anti-authoritative relationship where the participants have the freedom to influence the research agenda (Råheim et al., 2016). Researchers who allow for shifts in authority during participant encounters must ensure reflexive self-awareness is maintained, so there is no ambiguity attached to potential knowledge claims (Råheim et al., 2016). An initial working relationship was established with the existing personal and professional contacts whom I purposively targeted for participation. Initial emails and phone calls were conducted to evaluate whether the potential participants were interested. Repeated interactions using phone, email, social, and professional media were used to strengthen relationships and generate trust. To establish a nonauthoritarian relationship, I thanked each participant for sharing their advanced knowledge and strategies related to the topic, making it clear that I was a novice in the subject area.

Research Method

As with all scholarly research, the appropriate method and design will depend on the primary research questions (Hamilton & Finley, 2019). My study's primary research question sought to uncover M&S implementation strategies used by some IT project managers supporting military organizations. The data required to address my research question included human knowledge, experience, opinions, and real-world context. Research requiring contextually rich data will also require a qualitative method (Maramwidze-Merrison, 2016). Some scholarly researchers believe qualitative methods are the only way to uncover people's experiences, attitudes, and feelings in context (Amiri et al., 2016). Furthermore, Hamilton and Finley (2019) found qualitative methods invaluable when investigating how and why implementation best practices fail or

succeed. Fundamentally, qualitative research is the most appropriate method of producing knowledge when a gap exists between theory and practice (Makaci et al., 2017).

Quantitative methods are appropriate for testing treatments, interventions, or correlations between variables (Yates & Leggett, 2016). Quantitative studies are also useful for describing a given population's trends and opinions (Yates & Leggett, 2016). Additional quantitative inquiry qualities include rigor demonstrated through validation, reliability, and generalizability (Mandal, 2018; Rapport et al., 2015). In quantitative studies, generalizability is a byproduct of reliable statistical procedures applied to quantitative data (Venselaar & Wamelink, 2017). Researchers can reduce, if not eliminate, bias when taking a quantitative approach (Yates & Leggett, 2016). However, despite high degrees of precision, quantitative data is limited by the absence of rich, in-depth descriptions only found in qualitative research (Yates & Leggett, 2016).

Moreover, if a quantitative method were to uncover an intriguing phenomenon, it would be impossible to ask probing questions for clarity in the confines of the original study (Van De Weerd et al., 2016). Fundamentally, quantitative research cannot uncover the how and why behind the phenomenon like qualitative research can (Yates & Leggett, 2016). Because my study was not designed to test treatments, interventions, or correlations between variables, I did not select a quantitative methodology. Moreover, my study required rich, in-depth descriptions surrounding the phenomenon, which are not inherently supported by quantitative research. To get to the heart of the phenomenon, I needed the flexibility to administer probing qualitative questions when needed.

As with qualitative and quantitative methods, using mixed methods will depend on the research question (Plano Clark, 2019). Investigators can only answer a mixed-

method question by integrating both qualitative and quantitative data (Plano Clark, 2019). In addition to answering research questions that require two methods, a mixed-methods approach can be used as a follow-up to investigate other unexpected results (Steinmetz-Wood et al., 2019). Studies that use a mixed-methods approach combine at least one qualitative and one quantitative method to capitalize on the strengths while minimizing the integrated methods' weaknesses (McCrudden et al., 2019; Steinmetz-Wood et al., 2019). Despite the potential benefits of using mixed methods, unique challenges can manifest. For instance, when conducting scholarly research, tension always exists between rigor and feasibility (Hamilton & Finley, 2019). Rigorous studies incorporating mixed methods demand more time, effort, and expertise than mono-method studies (McCrudden et al., 2019). Also, mixed methods researchers should be experienced in using both qualitative and quantitative methods (McCrudden et al., 2019; Steinmetz-Wood et al., 2019). Because most researchers are not skilled or comfortable with qualitative and quantitative methods (Steinmetz-Wood et al., 2019), most mixed methods studies require a team of researchers (McCrudden et al., 2019).

My primary research question was not a mixed-method question that demanded qualitative and quantitative methodologies. A qualitative approach was needed to uncover the how's and whys behind the successful M&S implementations in their real-world contexts. While the precision and rigor of quantitative inquiry are appealing, statistical correlations between variables would not have generated the implementation strategies needed to address the research problem.

Research Design

A multiple-case study was my research design. Research teams can use a multiple-case study to unearth the actual practices impacting a complex research phenomenon (Grubic, 2018). Multiple-case studies' core objective is to put what is learned into practice (Alpi & Evans, 2019). Investigating multiple cases increases external validity and generalizability, which are recognized limitations of single-case research (Grubic, 2018). When the research includes qualitative *how* and *why* questions, a case study design can go further by illustrating the linkages between pertinent real-world events (Makaci et al., 2017). A significant strength of multiple-case study design is the ability to explain whether findings exist across cases (Parjanen & Hyypiä, 2019; Singh et al., 2019). Before deciding on a specific qualitative research design, doctoral students should only consider designs that have been shown to support data saturation (Fusch & Ness, 2015). The aspects of case study design that support data saturation include interviews and thick and rich data (Fusch & Ness, 2015).

Furthermore, the ability to intentionally target a homogenous group of participants supports data saturation in case study research (Hamilton & Finley, 2019). Well documented saturation techniques make multiple-case study a viable research design. Additionally, the implementation of modern M&S technology in military organizations can be a complex endeavor. A multiple-case study design was needed to uncover actual practices used across organizations so that implementation strategies could be formed and put into practice. Incorporating multiple organizations was required to increase external validity by highlighting critical linkages and indicating whether the findings existed across cases.

Phenomenology is another popular qualitative design that utilizes observations and interviews for data collection (Qutoshi, 2018; Webb & Welsh, 2019). The purpose of phenomenology is to explain multiple people's lived experiences cognizant of the same phenomenon (Valentine et al., 2018; Webb & Welsh, 2019). The objective of phenomenology is not to solve problems but rather to describe the subjective beliefs surrounding a shared lived experience (Qutoshi, 2018; Valentine et al., 2018; Webb & Welsh, 2019). The methodology's heavy philosophical nature has led to scholars describing phenomenology as inherently complex (Errasti-Ibarrondo et al., 2018) and messy (Qutoshi, 2018). According to Errasti-Ibarrondo et al. (2018), many variations exist, making it extremely difficult to find straightforward guidelines for conducting phenomenological research. My research aimed not to describe the participant's beliefs related to a lived experience but to gather and share actionable strategies to solve a problem.

Some researchers consider ethnography to be one of the most in-depth research designs available. In addition to transcribing what participants say they have done, ethnography allows the researcher to see what is happening (Baskerville & Myers, 2015). Ethnographers are particularly interested in capturing the differences between what participants say and what they do (Ackerman et al., 2015; Baskerville & Myers, 2015). In addition to qualitative interviewing, ethnography relies heavily on participant observations (Ackerman et al., 2015; Baskerville & Myers, 2015; Cowdean et al., 2019; Råheim et al., 2016). Not only are participant observations critical to the success of ethnography (Cowdean et al., 2019), the effective implementation of the practice requires an extended period of time spanning months if not years in the field (Ackerman et al.,

2015; Baskerville & Myers, 2015; Cowdean et al., 2019; Goulden et al., 2016). Many ethnographic studies' downfall traces back to insufficient time spent conducting participatory investigations (Cowdean et al., 2019).

Conversely, ethnographers who spend adequate time with the participants must guard against *going native,* which refers to a lack of critical distance needed to guard against becoming overly encultured (Goulden et al., 2016). In practice, ethnography is often eliminated as a viable research design because the sustained periods of required fieldwork would exceed the time and funding allotted to the proposed study (Ackerman et al., 2015). Employing an ethnographic design would have put my study in jeopardy of exceeding the time restraints applied to doctoral research, and the military aspect of my study was also a limiting factor. Even if some military organizations had allowed an external researcher to conduct extended field observations, my own military employer would not authorize my participation. For these reasons, a multiple-case study design was a better fit than an ethnography design.

Population and Sampling

It is common knowledge that alignment is a vital characteristic that researchers should demonstrate throughout a study. Alignment includes clear linkages between the primary research question and the method, design, conceptual framework, data collection, and analysis techniques (Twining et al., 2017). Likewise, strategic alignment in qualitative research requires a population of potential participants who possess the knowledge and experience required to provide meaningful insight into the primary research question (Maramwidze-Merrison, 2016). The principle of alignment continues in that the nature of the population and sample directly impacts the credibility,

transferability, dependability, and confirmability of qualitative studies (Constantinou et al., 2017). Therefore, it is vital to articulate key elements related to the population and sample in qualitative research.

A qualitative research design's full and transparent disclosure is not complete without anonymous background information related to individual and organizational participants and how and why they were selected (Malsch & Salterio, 2016). One of the primary goals of all qualitative research is to capture the knowledge, experience, and understanding of those who can provide meaningful insight into the defined research problem (Malsch & Salterio, 2016). Meyer et al. (2019) describe suitable participants of multiple-case studies as expert informants. Knowledgeable and insightful are two of the most commonly used descriptors associated with participant selection (Malsch & Salterio, 2016; Maramwidze-Merrison, 2016; Zondag et al., 2017). Furthermore, qualitative researchers should select participants capable of providing the real-world context surrounding the phenomenon under investigation (Zondag et al., 2017). The selection criteria needed to choose knowledgeable, insightful, and experienced participants capable of speaking to my research phenomenon in context included:

- must be a full-time civil service employee;
- have at least seven years of IT experience;
- participated in the successful implementation of M&S technology for military organizations located on the East Coast of the United States;
- possess knowledge of the entire implementation process.

After selecting a research topic and choosing an appropriate design, one of the most important tasks is determining an adequate sample size (Marshall et al., 2013). Determining an adequate qualitative sample size a priori, before the research begins, is problematic and nearly impossible (Blaikie, 2018; Sim et al., 2018; Smith, 2018). However, for the sake of various approval and ethics committees, qualitative researchers are often expected to state the sample size in advance (Blaikie, 2018; Marshall et al., 2013; Sim et al., 2018; Smith, 2018). Instead of focusing on the number of participants, qualitative researchers are encouraged to seek knowledgeable informants, often leading to small sample sizes (Hamilton & Finley, 2019; Malsch & Salterio, 2016; Sim et al., 2018; Smith, 2018). Furthermore, small samples are justified when the research design includes (a) a narrow research scope, (b) a homogenous sample, and (c) the use of an established conceptual model (Malterud et al., 2016; Sim et al., 2018). Determining the sample size based on precedent is also a common approach (Marshall et al., 2013; Sim et al., 2018). Case studies typically include at least six participants but no more than 12 when the sample is homogenous (Dai et al., 2019; Low, 2019). At Walden University, eight is the average number of participants interviewed in Doctor of IT studies, as of December of 2019. Based on the narrow scope, conceptual model, and qualitative multiple-case study design, my study's ideal sample size was 9-15 participants. In my multiple-case study, three different military organizations represented the cases. For each case, I interviewed at least three civil servants and continued interviewing until I demonstrated thematic saturation. Despite the established factors I used to estimate my sample size for approval purposes, the most common principle used to determine a

qualitative sample's adequacy is saturation (Hennink et al., 2017; Low, 2019; Marshall et al., 2013).

Scholars often describe saturation as the point in qualitative data collection where no further insight would be gained by conducting additional interviews (Dai et al., 2019; Hamilton & Finley, 2019; Malsch & Salterio, 2016). In reality, reaching saturation is a matter of degree because there will always be new insights to uncover (Low, 2019). More accurately, the goal of saturation is to recognize when the data's quality has peaked, and conducting additional interviews would produce rapidly diminishing returns (Marshall et al., 2013). While it may be easy for researchers to identify saturation, it is essential to describe the process used to determine (Malsch & Salterio, 2016). Additionally, qualitative researchers can apply saturation in the context of theoretical saturation, data saturation, or thematic saturation (Hennink et al., 2017; Sim et al., 2018). In all qualitative research, thematic saturation is the gold standard (Squires & Dorsen, 2018). In my study, I applied thematic saturation as initially described by Guest et al. (2006) and later refined by Ando et al. (2014). In both seminal works, the authors reached thematic saturation after conducting 12 interviews from a relatively homogeneous group of participants (Ando et al., 2014; Guest et al., 2006).

According to Marshall et al. (2013), both the sample size and saturation are directly impacted by the sampling method. Qualitative researchers use purposeful sampling methods to intentionally select participants who can add depth and richness of data (Mandal, 2018). Of the 16 or more types of purposeful methods reported by Guest et al. (2006), I chose a purposive and snowball sampling strategy, which according to Singh et al. (2019), is a best practice for selecting the most appropriate individuals per case.

Researchers who combine purposive sampling with snowball sampling target participants who are confirmed experts (Courtenay et al., 2018) considered by the investigators to be information-rich interviewees (Norris et al., 2020). The investigators' personal and professional contacts are used for the first round of recruitment (Davies & Christie, 2017; Eisele et al., 2020; Santos-Nunes et al., 2017). Researchers use snowball sampling to expand upon the initial list of purposively recruited interviewees with the intent of maintaining a homogeneous sample (Davies & Christie, 2017). In snowball sampling, participants are asked to recommend additional interviewees who can provide insight into the research topic (Hamilton & Finley, 2019; Malsch & Salterio, 2016). Researchers use snowball sampling to recruit additional subjects until saturation is met (Naderifar et al., 2017). Qualitative researchers who incorporate snowball sampling can use prior relationships and social networks to identify additional participants, increasing the probability of uncovering reoccurring themes (Sim et al., 2018). Naderifar et al. (2017) noted that snowball sampling is ideal when the participants are difficult to access, which was the case in my research. In my study, I used purposive sampling to select a small homogeneous group of ideal participants who meet the participation criteria. Furthermore, I used snowball sampling to add additional participants until I was able to demonstrate saturation.

The interview setting is another key component related to the population and sample. The interview venue can impact the overall data collection process (McGrath et al., 2018). A best practice in qualitative research indicates that interviewers should schedule all interviews at a time and location convenient for the interviewee (DeJonckheere & Vaughn, 2019; McGrath et al., 2018). In general, public places are not

ideal for interview locations (DeJonckheere & Vaughn, 2019). Instead, researchers should conduct interviews in comfortable but private locations that limit the possibility of interruptions (DeJonckheere & Vaughn, 2019; McGrath et al., 2018). Finding a room or office that has a closable door will help with privacy and ensure the interview can be heard and recorded easily (DeJonckheere & Vaughn, 2019). In modern academic studies, the location could mean face-to-face online using video teleconferencing solutions like Skype (Heath et al., 2018). Some participants may feel more comfortable being interviewed over the phone or using email correspondence (Heath et al., 2018; Hershberger & Kavanaugh, 2017). Being flexible with the interview location will make the participants more comfortable and increase participation (Heath et al., 2018). In my study, I encouraged each participant to choose an interview time and location that accommodated their needs. I made every effort to conduct interviews in quiet, private locations that discouraged interruptions and supported audio recording. Even though face-to-face interviews are considered the gold standard (Heath et al., 2018), online face-to-face, phone, and email correspondence was presented as alternate interview settings so that potential participants felt comfortable, which increased participation.

Ethical Research

In addition to limiting bias (Goodell et al., 2016), providing contextual information (Phillippi & Lauderdale, 2017), and practicing reflexivity throughout the study (Venselaar & Wamelink, 2017), ethical research includes protecting human participants (Laage et al., 2017). If ethical issues arise during data collection, the researcher must act in the participant's best interest (Goodell et al., 2016). It is relevant to note that Institutional Review Boards (IRB) provide ethical oversight and are responsible

for defining ethical research and how it is conducted (Clapp et al., 2017). Most IRB members use the Belmont Report as a reference when reviewing research proposals (Laage et al., 2017). They expect researchers to demonstrate respect for persons, beneficence, and justice (Kamp et al., 2019).

Scholars can obtain respect for persons through an informed consent process (Kamp et al., 2019), a Walden IRB requirement. The consent form was presented to each potential participant. Informed consent requires the participants to be aware of the study's purpose, potential risks, if any, and possible benefits (Moss et al., 2019). The informed consent form should clearly state that participation is voluntary, and participants can withdraw from the study at any time (Kamp et al., 2019). Potential participants were reminded in the invitation email, in the consent form, and at the start of the interview that participation was voluntary and can be terminated at any time, for any reason. Beneficence involves taking steps to protect each participant and maximize participation's potential benefits (Kamp et al., 2019). The identity of individuals and organizations was be kept anonymous and confidential. Allowing participants to sign with a cross or doodle if they do not want to provide a recognizable signature demonstrates the researcher's willingness to protect the participants' identity (Moss et al., 2019). According to Kamp et al. (2019), fully disclosing the process used to select participants is one way researchers demonstrate justice, especially when participation could be considered therapeutic (Laage et al., 2017). Not only can sharing one's stories be therapeutic, but many participants perceive the opportunity to be heard by a wider audience as beneficial (Moss et al., 2019).

Furthermore, I provided the results of my study to the participants, which, according to Moss et al. (2019), represents a possible participation incentive. In addition to being given a copy of the final study, the consent form listed other possible participation incentives. One possible incentive is the participants' opportunity to contribute M&S implementation strategies to the larger body of IT practitioners.

Obtaining IRB approval is a critical component of conducting ethical research (Clapp et al., 2017). Walden University's approval number for this study is 05-04-20-0635823 and it expires on May 3, 2021. Additionally, the Walden IRB approval number and all required agreement documentation were provided verbatim to the participants. All data gathered for the study will be encrypted on an external hard drive and stored safely for 5 years to protect the participants' confidentiality.

Data Collection Instruments

In qualitative research, the researcher is the primary data-gathering instrument (Neuman, 2014). Besides being the primary research instrument, the qualitative researcher develops and monitors additional data gathering processes (Lattal & Yoshioka, 2017). In my qualitative study, I served as the primary data collection instrument, and I developed and monitored the implementation of additional data gathering processes. An interview protocol (see Appendix) was used to conduct semistructured interviews while taking field notes of the observations I made. Furthermore, I gathered and incorporated various sources of relevant documentation for triangulation purposes. In case studies, interview data, observations, organizational documents, and archival documents are valid sources of data for triangulation and sense-making (Alpi & Evans, 2019).

Interviewing is the most crucial method of collecting data in qualitative case studies (Alpi & Evans, 2019) because of the ability to traverse a real-world phenomenon from the informant's perspective (Chirumalla et al., 2018). Of the various interview techniques available, semistructured interviews are the most common type used in qualitative research (DeJonckheere & Vaughn, 2019). Semistructured interviews can be used in case studies to (a) maximize data extraction from the interviewees, (b) follow-up on provided comments, (c) ask for clarifications, and (d) administer additional probing questions when needed (Van De Weerd et al., 2016). Qualitative researchers should always use a flexible interview protocol when conducting semistructured interviews (DeJonckheere & Vaughn, 2019). An interview protocol is a document that contains an outline that interviewers should follow so that each interview is conducted similarly (Goodell et al., 2016). According to Goodell et al. (2016), an interview guide should contain (a) an introduction, (b) a reference to the consent process, (c) demographic questions, (d) an icebreaker, (e) the main interview questions, (f) probes, (g) a review process, and (h) a conclusion. Furthermore, interview protocols ensure the initial questions are not leading or hint at the expected answer while simultaneously allowing the participant to expound on the topic in detail, without interruption (Malsch & Salterio, 2016). An interview protocol incorporating best practices from Goodell et al. (2016) was used in my study to conduct semistructured interviews. I applied member checking for the review process after interview sessions to validate my interviews' interpretation. The primary interview questions and probes have been referenced in the table of contents and are provided verbatim in Section 1 and the interview protocol found in the Appendix.

Member checking is a commonly used method of increasing the validity, trustworthiness, and credibility of qualitative research (Raskind et al., 2018). Qualitative researchers may use multiple forms of member checking at different points in the research process. Member checking, also known as respondent validation (Attia & Edge, 2017; McGrath et al., 2018), was used in my study to enhance the reliability and validity of the data collection process. This form of member checking was used during the data gathering process to make corrections before moving forward in the study, as recommended by Yates and Leggett (2016). Qualitative researchers accomplish this form of member checking by either asking for feedback during an interview or at the end by summarizing the transcriptions (Goodell et al., 2016). At the end of each interview, I reviewed my interpretation of the interviews with the participant and allowed the interviewee to provide corrections or clarifications.

Data Collection Technique

My primary data collection technique was built upon the interview guide by incorporating additional best practices for conducting qualitative semistructured interviews. Following the guidelines shared by both DeJonckheere and Vaughn (2019) and McGrath et al. (2018), interviewees were allowed to choose the interviews' time and location. When possible, the interview location should be quiet and private (DeJonckheere & Vaughn, 2019; McGrath et al., 2018). I obtained permission to digitally record interview data because, according to Hamilton and Finley (2019), detailed recordings are the foundation of qualitative analysis. Field notes are an essential aspect of high quality and rigorous qualitative research (Phillippi & Lauderdale, 2017). Besides providing thick, rich contextual information, field notes can identify potential bias and

facilitate the initial coding process (Phillippi & Lauderdale, 2017). Each of these techniques was used in my study to conduct and record consistent qualitative interviews that tended to the needs of the participant while maximizing data collection.

Qualitative interviews provide an advantage over surveys when interpersonal contact is essential and when the ability to administer follow-up questions is ideal (Hamilton & Finley, 2019). A further advantage of qualitative interviewing is uncovering facts, stories, meanings, and relationships that cannot be easily observed (Maunganidze, 2019). A potential disadvantage of qualitative interviews is the cumbrous amounts of raw data that must be transcribed by the researcher or research team (McGrath et al., 2018). This disadvantage is especially true if the researcher procrastinates and does not transcribe and analyze data shortly after interviews are conducted (McGrath et al., 2018). The loose structure and interactive nature of semistructured interviews can be intimidating and challenging for inexperienced qualitative researchers (DeJonckheere & Vaughn, 2019).

Similarly, Lattal and Yoshioka (2017) noted that systematic training is usually required to become a skilled human instrument. Planning my data collection technique, preparing an interview guide, and relying on prior qualitative interview training served me well in the field. Moreover, each interview was digitally recorded and immediately transcribed and coded, usually within 48 hours of completing an interview. Member checking and triangulation were used in my study to strengthen further the reliability and validity of the data collection technique.

A commonly used form of member checking involves returning the interview transcripts or findings to the participants for validation or enhancement (Goodell et al.,

2016; Malsch & Salterio, 2016; McGrath et al., 2018). This form of member checking is beneficial as a sounding board for fledgling researchers seeking to validate data quality (McGrath et al., 2018). According to Smith and McGannon (2018), the literature often suggests that investigators can use member checking to validate the credibility of qualitative data and analysis and control researcher bias. Even though researchers are encouraged to use member checking to increase the trustworthiness of qualitative research, the method should be used in a controlled manner to limit excessive disagreements on interpretations (McGrath et al., 2018; Smith & McGannon, 2018). In my study, I contacted each participant after I developed my interpretation of each interview to schedule a follow-up Zoom session. Each participant received my interpretation of their interview via email before the Zoom session. Each participant was allowed to provide feedback on the accuracy and interpretation. If the interpretation was not accurate, I asked for clarification. If the information provided was new, more interviews were offered to ensure I reached data saturation. Member checking is an essential component of triangulation (Twining et al., 2017). As data collection and analysis continued, triangulation was incorporated to strengthen the findings' trustworthiness further.

Triangulation is another popular method of increasing the credibility and trustworthiness of qualitative research (Raskind et al., 2018). The triangulation concept originated from the geographic surveying domain of science, where a destination is verified by mapping its location to multiple known reference points (Varpio et al., 2017). In qualitative research, the technique involves cross-checking multiple data sources to investigate whether the results are homogenous (Moorley & Cathala, 2018). Researchers

can use multiple data collection techniques to support triangulation (Yates & Leggett, 2016). Data sources suitable for triangulation include semistructured interview data, publicly available information, internal documents (Malsch & Salterio, 2016), other documentation, and archival records (Alpi & Evans, 2019). Researchers who use triangulation to converge upon a single version of the truth are taking a postpositivist qualitative approach (Varpio et al., 2017). In my qualitative study, I used data triangulation to cross-check semistructured interview transcripts, field notes, scholarly documents, websites, and publicly available documents.

My secondary method of data collection was document review. I used publicly viewable documents as well as organizational documentation the participants were willing to share. The types of documents I requested were related to the best practices and M&S processes the interviewees discussed. Before the interview was over, I requested copies of any documents mentioned during the interview. The literature review uncovered critical phases of the M&S implementation process that require documentation and other artifacts. I requested additional data sources, including project charters, requirements documents, diagrams, conceptual models, and verification and validation test plans. In addition to reviewing military websites for M&S documents, I asked each participant for the address of their public websites to search for additional M&S documents relevant to the research topic.

In sum, my data collection technique involved following an interview protocol to administer semistructured interviews using open-ended questions and follow-on probes consistently. I conducted the interviews in private locations at a date and time that accommodated the participant. Before the interview started, I obtained verbal permission

to record the interview digitally, and I captured field notes throughout the interview. Typically, within 48 hours, I transcribed both the transcript and field notes and imported both data sources into NVivo. My interpretation of the interview findings was sent to individual participants for feedback and participant validation. Supplemental documentation, including publicly available information, internal documents, archival records, and any additional publicly releasable documentation the participants were willing to share, were imported into NVivo as additional data sources needed for triangulation purposes.

Data Organization Techniques

In a recent study used to investigate modern qualitative data analysis practices, the researchers discovered that over 65% of the papers examined reported qualitative data analysis software (QDAS) for data preparation and management purposes (Raskind et al., 2018). Two of the longest-used (Woods et al., 2016) and most popular QDAS packages are Atlas.ti and NVivo (Raskind et al., 2018). The literature distinguishes between using QDAS software for data management/organization purposes versus data analysis (Woods et al., 2016). Data management refers to the process of managing and organizing expanding datasets in preparation for data analysis, which in turn refers to the qualitative coding process (Sapat et al., 2017; Woods et al., 2016).

Even though modern QDAS applications can store and organize documents, field notes, videos, and imagery, interview transcripts constitute over 73% of data managed using QDAS applications (Woods et al., 2016). In addition to managing and organizing large datasets, QDAS applications can produce visual representations capable of stimulating the researcher's understanding and interpretation of the data (Salmona &

Kaczynski, 2016; Sapat et al., 2017). Moreover, the use of QDAS applications can promote trustworthiness and rigor (Woods et al., 2016), not because of the software's powerful data analysis capabilities but from the enhanced interpretations made transparent through the data organization (Sapat et al., 2017). I used the NVivo QDAS application for data management, organization, sorting, and secure storage during data collection and analysis. After the data analysis phase, I saved all raw data in an encrypted NVivo project file (.nvp extension) that I transferred to an external thumb-drive. The external thumb-drive will be stored in a locked container for 5 years. The ability to manage secure backups in multiple locations is a recognized strength of QDAS applications (Salmona & Kaczynski, 2016).

Data Analysis

Data analysis is a powerful step in qualitative research, yet this vital stage is least understood (Raskind et al., 2018). Qualitative researchers need to be transparent in the intentional application of rigorous data analysis (Raskind et al., 2018). According to Saldana and Omasta (as cited in Raskind et al., 2018), there is no single correct way to conduct qualitative data analysis. Nevertheless, the goal should always be to produce work that benefits the study, stakeholders, and the broader scientific body (Hamilton & Finley, 2019). No matter which specific data analysis method is used by an investigator, the typical process involves transcribing interview data, reviewing the data, applying codes, then categorizing the codes to look for patterns and themes (DeJonckheere & Vaughn, 2019). Before selecting a specialized data analysis method, the qualitative study's composition, including the research questions, participants, data types, and context, should be used to inform the decision (Raskind et al., 2018).

After considering the purpose of my multiple-case study and reviewing the literature, the data analysis process, I selected was within-case and cross-case thematic analysis. Braun and Clarke (2006) contributed a seminal work on qualitative thematic analysis that provided a straightforward and systematic implementation process that is easy for beginning researchers to learn. Many contemporary researchers are using Braun and Clarke's (2006) thematic analysis process to conduct within-case and cross-case analysis in qualitative multiple-case studies that incorporate interview data (Alkhuraiji et al., 2016; Dillworth et al., 2019; Sandstrom & Reynolds, 2019; Swann et al., 2016). The six steps in the thematic analysis include (a) familiarization with the data, (b) coding the data, (c) searching for themes, (d) reviewing the themes, (e) defining and naming themes, and (f) producing the final report (Braun & Clarke, 2006; Dillworth et al., 2019; Sandstrom & Reynolds, 2019). The within-case thematic analysis involves applying all six thematic analysis steps for each case individually (Alkhuraiji et al., 2016; Dillworth et al., 2019; Sandstrom & Reynolds, 2019; Swann et al., 2016). Qualitative researchers conduct cross-case analysis once all individual case reports are complete to identify themes present in multiple cases (Alkhuraiji et al., 2016; Dillworth et al., 2019; Sandstrom & Reynolds, 2019; Swann et al., 2016). While investigators can use tables to manually identify cross-case themes (Singh et al., 2019), it is more common for researchers to use a QDAS application such as Atlas.ti or NVivo (Alkhuraiji et al., 2016; Dillworth et al., 2019; Sandstrom & Reynolds, 2019). When researchers use thematic analysis in a multiple-case study, the last step is to produce a final multiple-case report (Sandstrom & Reynolds, 2019).

The increased use of QDAS applications confirms that researchers cannot conduct modern qualitative research without using computers (Salmona & Kaczynski, 2016). Utilizing QDAS applications during data analysis simplifies the data coding process and provides powerful search and visualization capabilities (Salmona & Kaczynski, 2016; Sapat et al., 2017). While traversing the data, relevant sections of text can be assigned a code that makes for easy indexing and retrieval of every section of data assigned the same code (Woods et al., 2016). This coding functionality also supports constant comparison and analysis of old and newly coded data (Salmona & Kaczynski, 2016; Woods et al., 2016). Reflexive notes, memos, and field notes can be inserted using the QDAS and linked to coded data (Salmona & Kaczynski, 2016; Sapat et al., 2017). Researchers are encouraged to record notes explaining their analytical decisions and reasoning, which provides proof of the analytical process (Sapat et al., 2017), and provides an audit trail (Salmona & Kaczynski, 2016). The inserted notes and memos become additional data sources investigators can triangulate against the coded transcripts and other data sources inserted into the QDAS dataset (Salmona & Kaczynski, 2016). These QDAS features promote increased trustworthiness through the analytical process's transparency (Salmona & Kaczynski, 2016; Sapat et al., 2017; Woods et al., 2016).

Qualitative researchers must work intimately with the data to uncover emerging themes and apply their unique interpretation process to tie the themes back to the primary research question (Hamilton & Finley, 2019). Knowledge gained during the literature review, especially related to the selected conceptual framework, was used to inform theme development and the presentation of findings. Qualitative researchers should consider deriving initial categories and descriptions of themes from the relevant literature

and findings published in similar studies (Vaismoradi et al., 2016). Researchers should use the conceptual framework selected to guide the research design to guide and inform qualitative data analysis (Hamilton & Finley, 2019; Salmona & Kaczynski, 2016). According to Raskind et al. (2018), a well-established framework should be used by investigators to inform all data analysis, leading to conceptual coherence between themes.

The NVivo QDAS application was used in my study to support within-case and cross-case thematic analysis. Once I imported a transcript into NVivo, I attached the initial codes I recorded in my field notes and continued the coding process. All six steps for thematic analysis was applied to each transcript in a case organization. Field notes, reflexive memos, and notes documenting analytical decisions were linked to coded data and used for triangulation purposes. Themes uncovered during the literature review and the conceptual framework were used to inform the thematic analysis and interpretation of themes. I used newly published articles related to the uncovered themes to update the literature review and illuminate the findings. Codes, themes, quotes, matrices, and informative visuals were extracted from NVivo, and incorporated into the research findings. Once I completed all interviews for each case organization, I used the NVivo QDAS application to conduct a cross-case analysis looking for themes present across cases. Because I conducted a multiple-case study, the final thematic analysis step was to produce a multiple-case report of the research findings.

Reliability and Validity

All scholarly research is judged based on specific quality indicators. The quality of quantitative studies is evaluated based on internal validity, external validity, reliability,

and objectivity (Connelly, 2016; Constantinou et al., 2017; Mandal, 2018). Each of the four quantitative markers has an equivalent quality standard in qualitative research. The four corresponding criteria used to assess qualitative research include credibility, transferability, dependability, and confirmability (Connelly, 2016; Constantinou et al., 2017; Mandal, 2018). Table 2 provides a comparison of the two sets of markers. Because most qualitative analysis involves interpretation, the results can present contrasting meanings for different readers (Mandal, 2018). Consequently, researchers can find it challenging to demonstrate quality and trustworthiness (Mandal, 2018). Therefore, qualitative researchers should address each of the four quality criteria to demonstrate the research's reliability and validity (Mandal, 2018).

Table 2

Comparison of QUAL and QUAN Quality Marker

Category	Method	Criteria	Definition
Validity	QUAN	Internal Validity	Demonstrates the study measures what it claims it is measuring.
	QUAL	Credibility	Refers to the extent to which the findings reflect reality.
	QUAN	External Validity	The extent of the results can be generalized.
	QUAL	Transferability	Relates to the transferring of the results to other situations or individuals.
Reliability	QUAN	Reliability	Shows that the study elicits similar results over time.
	QUAL	Dependability	Ensures other researchers can repeat the study.
	QUAN	Objectivity	Signifies that the researchers' ideas and biases do not influence the research process.
	QUAL	Confirmability	Results reflect their participants' experiences and thoughts and not their own ideas and values.

Note. Adapted from Constantinou et al. (2017).

The following sections provide more insight into how credibility, transferability, dependability, and confirmability were used to promote reliability and validity in my qualitative multiple-case study.

Credibility

In qualitative research, creditability is the equivalent of internal validity and refers to the degree to which the findings mirror reality (Connelly, 2016; Constantinou et al., 2017; Mandal, 2018). Researchers often describe credibility as the degree to which the findings are believable (Mandal, 2018; Williams et al., 2019). Scholars can use multiple

techniques to demonstrate qualitative credibility. According to Constantinou et al. (2017), qualitative researchers should describe the research phenomenon in detail to increase credibility. Providing thick and rich descriptions helps readers determine if the participants' stories and the researcher's interpretations are believable and appropriate (Williams et al., 2019). Scholars should provide enough detail, so the credibility of the selected qualitative research design, objective, and data collection process can be assessed and established (Connelly, 2016; Rapport et al., 2015).

Another technique used to establish credibility is member checking (Connelly, 2016; FitzPatrick, 2019; Liao & Hitchcock, 2018; Mandal, 2018). Researchers can use member checking to validate the findings' credibility by allowing participants to review the transcripts or interpret the transcripts (FitzPatrick, 2019; Mandal, 2018). In this way, the participants confirm the credibility of the research results (FitzPatrick, 2019). Member checking was used to validate my interpretation of each participant's interview and transcript. Lastly, scholars can use data triangulation to reinforce findings' credibility (FitzPatrick, 2019; Liao & Hitchcock, 2018; Mandal, 2018). Even though illustrating the same results in multiple data sources can indicate credibility and an absence of bias, triangulation does not guarantee qualitative validity (FitzPatrick, 2019). I used multiple credibility techniques in my multiple-case study. Member checking, data triangulation, and thick and rick descriptions were used in my study to validate the credibility and trustworthiness of the research design, data collection, and interpretation of results.

Transferability

In qualitative research, transferability is the equivalent of external validity or generalizability (Constantinou et al., 2017; FitzPatrick, 2019; Mandal, 2018). In general,

research findings should be applicable beyond the original study's context (Mandal, 2018). In qualitative research, transferability refers to research findings that can be transferred to other settings or contexts by the reader or other researchers (Constantinou et al., 2017; Mandal, 2018; Rapport et al., 2015; Williams et al., 2019; Zondag et al., 2017). Rapport et al. (2015) described transferability as the concept that scholars could present a given study as one example within a broader family of similar investigations. Qualitative researchers support transferability by providing rich, detailed contextual descriptions of the phenomenon (Connelly, 2016; Constantinou et al., 2017; Mandal, 2018). The provided contextual information should include details related to the participants, locations, and data analysis (Connelly, 2016). Details surrounding the sampling method and recruitment strategy can further support transferability (Rapport et al., 2015). Reaching data saturation is another indicator of transferability. More precisely, saturation is an indicator of external validity because it connects to the validity of the data set and research results (Nascimento et al., 2018). Saturation is deeply embedded in the logic of qualitative validity (Braun & Clarke, 2019). According to Constantinou et al. (2017), saturation is considered the crown jewel of qualitative research validity. Failure to reach saturation can negatively impact both the research results' validity and transferability (Fusch & Ness, 2015).

Beyond detailed contextual information surrounding the research setting and demonstrating saturation, the qualitative design can impact transferability. Qualitative researchers can implement a multiple-case study design to increase external validity (Grubic, 2018; Makaci et al., 2017; Nguyen et al., 2019; Singh et al., 2019). When an investigator can demonstrate similar results across cases using cross-case analysis, the

findings are less vulnerable to generalizability criticism (Singh et al., 2019). Increased transferability was inherent in the use of a multiple-case study design that included cross-case analysis. Data collection continued until I could transparently demonstrate thematic saturation. Furthermore, I provided thick and rich contextual information related to the phenomenon and research settings so that future readers can determine whether the findings transfer to other settings and contexts. According to Connelly (2016), one of the goals for qualitative transferability should be to paint a vivid picture of the entire research process that will resonate with the readers.

Dependability

In qualitative research, dependability is equivalent to reliability (Connelly, 2016; Constantinou et al., 2017), yet researchers cannot check for reliability in the same way as quantitative research (Mandal, 2018). The primary way qualitative researchers ensure dependability is to properly document the research design, data, and analysis so other researchers can replicate the study (Constantinou et al., 2017; Mandal, 2018). Qualitative researchers can increase dependability by using research notes and audit trails to document important research decisions (Connelly, 2016; Mandal, 2018). For qualitative dependability, it is essential to record decisions that impact data coding and analysis (Bengtsson, 2016; Constantinou et al., 2017). The panacea of qualitative dependability would provide such extensive detail that other researchers could use the study as a prototype model for similar research (Rapport et al., 2015). Besides providing thick and rich descriptions of the entire research process, I maintained detailed research notes and an audit trail using the NVivo QDAS application, as described in the data analysis

section. The dependability goal was to provide extensive details documenting the entire research protocol so that future researchers could reproduce the study.

Confirmability

In qualitative research, confirmability is comparable to objectivity (Connelly, 2016; Constantinou et al., 2017; Mandal, 2018; Rapport et al., 2015). More specifically, qualitative confirmability refers to objectivity applied during data collection and analysis (Mandal, 2018). The objective is to link the research findings back to participant data, not the researcher's ideas or assumptions (Constantinou et al., 2017; Moorley & Cathala, 2018; Rapport et al., 2015). As with credibility, transferability, and dependability, confirmability requires rich, detailed descriptions (Constantinou et al., 2017). In support of confirmability, qualitative researchers should identify and report any potential bias that could have influenced the findings (Moorley & Cathala, 2018). Qualitative researchers can employ member checking to amplify confirmability (Connelly, 2016; Rapport et al., 2015). Investigators use this form of member checking to ask the participants to confirm the transcript interpretations' accuracy and a summary of the findings (Goodell et al., 2016). According to Sapat et al. (2017), QDAS software such as NVivo can also help establish confirmability by visualizing how the participant data links to themes and interpretations. Successfully demonstrating confirmability is an indicator of quality research (Mandal, 2018). In line with my ethical qualitative researcher's role, reflexivity and memoing was used to control bias and support objectivity during data collection and analysis. All research notes and memos were linked to the data using NVivo. Furthermore, I returned my interview interpretations to individual participants for member checking. Last, I used detailed descriptions and the NVivo QDAS application to

link the data collection and analysis back to the participants' ideas and opinions. Table 3 provides an overview of key methodological strategies presented in this section.

Table 3

Overview of Methodological Strategy Presented in Section 2

Research Component	Tasks
Data Collection	• Conduct and record semistructured interviews, following an interview protocol, while taking field notes. • Gather relevant organizational and archival documentation. • Transcribe interview transcripts within 48 hours, and use member checking to validate interpretations. • Import transcripts, field notes, and supporting documentation into NVivo and begin organizing and triangulating.
Data Analysis	• Conduct within-case analysis by applying the six steps of thematic analysis described by Braun and Clarke (2006) for each transcript in a case organization. • NVivo was used to conduct cross-case analysis to identify codes and themes present across multiple cases. • NVivo assisted with coding, theme identification, triangulation, reflexive memos, and auditing of analytical decisions.
Credibility	• Produce thick and rich descriptions of the participants' views, beliefs, and opinions surrounding the research phenomenon. • Conduct member checking and triangulation of the research findings.
Transferability	• Provide thick and rich contextual descriptions of the research phenomenon, participants, locations, and data analysis. • Demonstrate thematic saturation using thick descriptions and the analysis trail and notes recorded in NVivo. • Illustrate cross-case analysis and themes present across cases.
Dependability	• Clearly document the specific research design and data analysis process in the final report. • Record detailed field notes, analytical decisions, and audit trails, and import all three into NVivo.
Confirmability	• Provide rich detailed descriptions that trace the research findings back to the participant data. • Produce illustrative visualizations that further links the themes and interpretations back to the participant data.

Transition and Summary

In Section 2, I discussed the composition of my multiple-case study. Core elements of the project, such as the research method and design, build upon the study's foundation, as presented in Section 1. The unique nature and challenges associated with accessing the ideal population and sample required purposive and snowball sampling. Essential qualitative methods, such as member checking, triangulation, and saturation, were used throughout data collection, organization, and analysis. Strategies used to ensure qualitative reliability and validity were explained in a systematic yet approachable fashion. Despite the importance of scholarly rigor and trustworthiness, human participants are the most cherished and protected components of qualitative research. Great care was taken to accommodate the needs and safety of the interviewees.

Moreover, I explained how I controlled researcher bias so that the participants' thoughts, opinions, and ideas could be captured and shared in the research findings. In Section 3, I will provide a presentation of findings using thick and rich details. The findings will be tied to professional IT practice and social change. As is expected with high-quality research, I will conclude Section 3 with recommendations for action and further research.

Section 3: Application to Professional Practice and Implications for Change

My study's foremost objective was to uncover M&S implementation strategies used by IT project managers working for U.S. military organizations. This section will discuss how the findings can be applied to professional practice and elicit social change. Specific subsections include an overview of the study, the presentation of findings, applications to professional practice, implications for social change, recommendations for action and further study, my reflections, and a conclusion to the study.

Overview of Study

The purpose of this qualitative multiple-case study was to explore strategies some IT project managers supporting U.S. military organizations use to implement modern M&S technology. Ten participants from three different military organizations participated in one-on-one interview sessions and provided 12 organizational documents for triangulation purposes. Seventy percent of the interviewees participated in follow-up member-checking sessions. Thematic analysis of the data uncovered three major and six minor themes that could be applied by IT practitioners as M&S implementation strategies.

Presentation of Findings

The primary research question that drove my research was: What strategies do some IT project managers supporting U.S. military organizations use to implement modern M&S technology? Each finding presented in the following section addresses the primary research question. The 10 interviewed participants were all full-time civil servants with at least 7 years of IT experience, who had also participated in the successful implementation of M&S technology. Data sources used for triangulation purposes

included the transcripts of 10 semistructured interviews with accompanying field notes and 12 organizational documents provided by the participants. The following major and minor themes were uncovered using systematic thematic analysis, compared to the existing literature, and examined through the chosen conceptual framework lens. Each of the main themes, which include (a) understanding the true requirements, (b) incorporating subject matter experts throughout implementation, and (c) anticipate and overcome persistent challenges, represent M&S implementation strategies being used by military organizations.

Theme 1: Understanding the True Requirements

The first theme supports the idea that project managers implementing M&S technology for military organizations must fully understand the user's requirements during the planning phase of implementation. If the requirements are not captured upfront, practitioners must resort to *discovery learning*, which was described as a painful process of learning the requirements along the way. All 10 of the participants stressed the importance of understanding the requirements when implementing M&S for military organizations. Three distinct subthemes emerged from the data (see Table 4). First, attention must be given to understanding the general M&S requirements, including a problem, a phenomenon, a scenario, and real-world systems. Second, understanding what data will be needed to feed the model or simulation is essential. Third, a decision-maker's output or expected metrics need to inform a clearly understood decision in the requirements gathering phase. Each of these subthemes will be presented in the following subsections.

Table 4

Subthemes for Understanding the True Requirements

	Interviews		Documents	
Subtheme	Count	References	Count	References
General M&S Requirements	10	63	8	73
Data Requirements	9	55	9	59
The Needed Metrics	6	16	7	54

Subtheme: General M&S Requirements

The importance of understanding the general M&S requirements was a common theme discussed by every participant. Participant C2P1 stated:

> One of the strategies that we use is to not go straight to the technology at first, but we try to understand what are their requirements, what are their needs, what are the issues that work, what are the pain points, what are we trying to solve first before we get into a lot of the technology and solution space. We work within the area of interfacing with the community on their modeling and simulation requirements up front.

Most general requirements revolve around the need to model and simulate existing and future real-world systems. Participant C2P4 explained that understanding the requirements involves understanding how the real-world system operates and functions. According to C1P1, a system could be a military vehicle, a weapon system, or even an individual soldier. Beyond a fundamental understanding of a real-world system, C1P3 stated that “it's critically important that we understand the context for how we represent different things within our models, so then we can ascribe the outcomes in a proper

context.” If a military model includes a warfighter, there will be a requirement to understand human actions and reactions given different conditions. C2P2 stated that M&S requirements could also include a crisis, physical vulnerabilities, or “a real-world no kidding scenario.” While C2P2 and C2P4 noted that generic military campaign scenarios could be used as M&S requirements, C3P1, C3P2, and C3P3 were often required to simulate real-life missions and distributed operations.

When describing the requirements gathering process, in addition to generic terms like “requirements” or “systems,” the participants commonly described the need to understand the problem, the need, the deficiency, the phenomenon, or the scenario. Participants C1P1, C1P3, C2P1, C2P2, C2P3, and C2P4 described documenting the scenario during the requirements gathering phase. Furthermore, the term scenario in the context of M&S requirements was mentioned in six of the participants' documents. When discussing the importance of understanding the M&S requirements, participant C2P1 stated, “To me, it goes back to the requirements, that's big time. It's the initial requirements phase trying to understand the deficiency and the issue that we're trying to address. That's the biggest thing.” Obtaining a clear understanding of the true M&S requirements is not a simple process. Practitioners must be diligent during the requirements gathering phase. Participant C1P3 described “a very methodical series of steps you're going to go through” to understand the *phenomenon* and describe the *problem* adequately. When discussing the challenge of fully understanding the true M&S requirements, participant C1P3 stated:

> Oftentimes they (customers) say, we want you to model this, and then walk away. And it takes a lot to then bring them back to the table and walk you through

what's necessary in order to get a new capability and do something like a model. We have to have that long discussion.

In addition to the functional M&S requirements, the participants expressed the importance of nonfunctional requirements such as usability. On multiple occasions, participants C2P2, C2P3, and C3P2 stressed the importance of creating M&S tools that were "easy to use" or not "difficult to use." Likewise, participants C2P3, C2P4, and C3P2 described the need to create M&S tools that are not "overly complex." Based on the participant's experiences, M&S tools that were overly complex or not easy to use were often rejected by the user community.

Many scholarly studies uncovered during the literature review confirm the importance of understanding the true M&S requirements before selecting methodologies, tools or moving to the design phase of implementation. The methodical series of steps used to capture the true requirements is often referred to as conceptual modeling. According to Abdelmegid et al. (2020), the defense sector provided some of the earliest references of conceptual modeling to understand modeling and simulation requirements. It was also noted that the process is often not explicitly described as conceptual modeling, but rather implicitly described as a significant effort in the planning phase used to understand:

- the purpose of the model,
- the scope of the model,
- an accurate depiction of the problem,
- the elements of the systems to be represented,

- the level of detail,
- the simulation requirements,
- the essential model components (Abdelmegid et al., 2020, p. 2).

Seo et al. (2017) stated that successful defense M&S relies on understanding the problem situation and the real-world target systems modeled, which could be an individual fighter, a warship, a submarine, or various other entities. Furthermore, the military community has developed its own terms, tactics, semantics, and taxonomies. Therefore the requirements must include these considerations to provide real-world context to the simulation (Seo et al., 2017). Implementing modeling and simulation to analyze the performance of military weapon and combat systems (Power et al., 2018), along with other defense and aircraft systems (Gregory et al., 2020), is an extremely complex endeavor. Military and defense systems have become increasingly complex, to the point where Model-Based Systems Engineering (MBSE) is now commonly needed to properly define M&S requirements (Gregory et al., 2020; Power et al., 2018). Significant rigor should be used upfront to fully understand complex military M&S requirements before moving on to the design and development phases of implementation. Processes used to capture complex requirements such as conceptual modeling and MBSE can be useful tools for IT project managers attempting to implement M&S technology for military organizations.

The two antecedent variables of TAM2 that apply to the theme are Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). Miranda et al. (2020) chose a user-centered approach that focused on essential user requirements ("usefulness") and being usable ("usability") when designing a medical simulation to increase user adoption. Van

der Linden et al. (2019) researched the use of conceptual modeling to capture requirements and noted that design features influenced by understanding the requirements had been found to influence perceived usefulness, affecting adoption rates. Likewise, Abas Sunarya et al. (2020) used PU and PEOU to evaluate whether the developers of an Aircraft Productivity System had successfully implemented the requirements according to the user's needs. Obtaining a clear understanding of what the users require can positively impact M&S adoption. Information technology professionals implementing M&S technology for military organizations should understand how each user requirement can be delivered in a feature that can enhance job performance and be easy to use.

Subtheme: Data Requirements

After the general M&S requirements are known, the next subtheme is understanding the data requirements. Each military M&S implementation will include specific data requirements that will directly impact the M&S results. Nine of the 10 participants expounded on the impact data has on M&S implementations, and nine of the 12 provided documents included the subtheme. Participants C1P3, C2P1, C2P2, C2P3, C2P4, and C3P2 described military models and simulations as needing large amounts of data and used descriptive words like "consume" and "feed" when describing the demand for data. According to participant C2P2, "The model is only as good as the data. If I have bad data, the models that I'm going to create are not going to portray the reality." Participant C1P1 similarly stated:

> It's one of those you know garbage in garbage outright, so if you do not have good data for the model to use, then all the algorithms in the model that are doing the calculations may work perfectly, but if the input data is skewed, then that's kind

> of a cascade effect, and perhaps the results of the simulation are not what they should be.

Therefore, not only large amounts of data, but high-quality data, are essential to successfully implement M&S. The nine participants who discussed data requirements used descriptors such as pedigree, high quality, authoritative, reviewed, and approved when describing the needed data.

Document C2D3 stated that “data are critical to M&S” and provided the following:

> Models need data, but not just any data. Therefore, when devising the methodology, it is critical to ensure that adequate data to support the chosen models will be available. These data may:
>
> - come from one or more standard databases,
> - be taken from authoritative, nonstandard databases,
> - be provided by an authoritative individual or organization,
> - be derived from other model results,
> - be deduced or invented based on the best available information.

Multiple participants also mentioned each of the acceptable data sources mentioned in document C2D3.

Models and simulations use data to shape the representations of systems and processes. In military M&S, data is used to define multiple entities, threats, vulnerabilities, interactions, behaviors, platforms, or systems. Incorporating accurate data for each element will have a direct impact on the results. Bad data for one element in a simulation can negatively impact other elements' behavior quickly, creating a ripple

effect that spreads through the model. Participants C1P1, C1P3, C2P1, and C2P2 all used weapon systems as examples of M&S entities that require significant data. Data for the physical characteristics, performance, accuracy, and lethality of a weapon are all needed. Participant C1P3 explained that in a simulation, weapon data would influence whether a simulated soldier could be shot from different distances and whether a hit was survivable or would result in a casualty. When it comes to a weapon system's simulated performance, C2P2 noted that terrain data was also crucial because elements such as trees impact how the firing will spread. Participant C1P1 explained how environmental data was needed because weapon systems perform differently under clear versus cloudy conditions or jungle environment versus a desert. Considering the impact and diverse interactions data have on the representations of systems and processes, it is clear why participant C1P3 stated, “it's very important that data has a level of pedigree and is scrutinized and reviewed at many levels.”

The topic of M&S data requirements and dependencies is well documented in the scholarly body of knowledge. According to Abdelmegid et al. (2020), the modeling team needs to identify data requirements during the planning phase when the team formulates the conceptual model. The objective of the M&S implementation, coupled with the conceptual model, will indicate the types of data needed to support implementation (Luminea et al., 2015). The credibility and quality of the M&S results are dependent upon quality input data that complements the conceptual model, making data collection one of the most critical aspects of M&S implementation (Luminea et al., 2015; Vanbrabant et al., 2019). Military M&S is a complex process that requires substantial amounts of data and dedicated computing resources needed to process the data (Shahin et

al., 2020). Military simulations require multiple data gathering methods to support the integration of diverse data types for vehicles, equipment, human behavior, anthropometric data, or even the clothing for individual soldiers (Davidson et al., 2021). Military and defense M&S often falls into large-scale systems modeling, which requires big data and large-scale data processing (Taylor, 2019). The term *Big Simulation* was coined to refer to large-scale simulations that depend upon big data input and produce big data output (Taylor, 2019). Military M&S practitioners should spend adequate time during the project planning phase to understand the data requirements needed to support the general M&S requirements. Multiple data collection methods and dedicated computing resources may be needed to accommodate big simulation data requirements. The quality of military M&S output has a direct correlation to the quality of the data input.

Examining this subtheme using a TAM2 lens indicates that output quality, which influences perceived usefulness, is the primary construct involved. Scholarly research designed to investigate information systems that depend on vital data indicates that information quality represents the user's perception of output quality (Bayram & Akın Ateş, 2020; Goh et al., 2017; Verma et al., 2018). The information quality or quality of the output data for simulations and models depends on the input data quality (Luminea et al., 2015; Vanbrabant et al., 2019). For decision-makers, output quality is of crucial importance (Verma et al., 2018). The input data should be complete, precise, come from multiple sources, and be accurate representations of real-world systems to increase the simulation output quality (Vanbrabant et al., 2019). When addressing M&S data requirements, practitioners should remember that input data directly impacts output

quality, consequently influencing usefulness. Practitioners supporting military M&S efforts should capture accurate real-world input data from multiple authoritative data sources.

Subtheme: The Needed Metrics

A vital aspect of capturing the true M&S requirements is understanding the needed metrics. The overall objective of military M&S is to inform a decision; therefore, the M&S results must be what the decision-maker needs. Six of the interview transcripts and seven of the documents provided by the participants included the subtheme. After explaining the importance of understanding the general M&S requirements, participant C1P3 stated:

> Obviously, the intended use for M&S it's typically to inform something. It's critical because based on the requirements, you can then start to identify what are essential things like metrics that I need to identify to develop in order to inform questions associated with the problem. And then, when you get to that point you start to take a look at, OK, what data do I need in order to generate this metric.

Other participants described the importance of understanding the needed results in slightly different ways. Participant C2P3 explained the process as:

> In a typical M&S project, you have requirements up front, different phases where they're gathering the data, they're getting the requirements ready, they understand the system to be modeled, and we understand the problem that requires us to build this model and simulation. This is where we need to consider what the results will look like at the end of the simulation and how can we make this simulation simple for anyone to understand because that is the whole point of doing it, after you

> input your data and build out the scenarios and it is simulating, you want other people to understand the results.

When explaining the requirements gathering process, participant C2P4 expressed the need to understand "what is the system you're trying to model and what is the best representation of that system to give you the metrics that you want to understand." It is important to remember that the metrics or results need to make sense to the decision-maker. Participant C2P4 further explained:

> It's super important that upfront, you have a way to use the output of your modeling simulations to provide information that's meaningful to a decision-maker, not meaningful to you, but meaningful to the decision-maker. I keep going back to metrics, but it's a huge part of it. Several times in my career I've had this great modeling and simulation solution, had these answers, and I took them to a Colonel or a General and tried to brief them, and I spent 20 or 30 minutes just explaining what the metrics meant because they were meaningless to them.

Metrics in the context of M&S results comes down to producing meaningful information that helps inform a decision. As C2P2 stated, "modeling and simulation is done for the sole purpose of making decisions." The need to produce meaningful results that inform decisions was described in various supplemental documents as well. In addition to confirming the goal of modeling and simulation "is to provide information for making decisions" document C2D3 advised M&S analysts to "Put yourself in the shoes of those who will receive the results. Ask the simple question, what information will allow the decision-maker to make a sound decision." Additionally, document C2D1 advised M&S practitioners to understand the "required metrics," obtain a "common

understanding of metrics," and to incorporate "quality metrics." Several of the documents (C1D1, C1D2, C2D3, C2D4) included detailed graphical representations of exemplary M&S metrics that could be used in briefings and presentations.

The available scholarly literature documents the importance of M&S efforts to produce meaningful metrics. While Zappia et al. (2017) noted that simulations are useful for generating a wide range of metrics, Rieb et al. (2017) pointed out that the appropriate metrics must be identified based on the needs of the decision-makers. A simple best practice is to ask the stakeholders which metrics are more salient for informing decisions, then customize simulation models to generate output in the requested metrics (Rieb et al., 2017). Military wargaming and M&S can be combined to convert qualitative results into quantitative metrics that better inform decision-makers (Mittal & Davidson, 2020). The types of M&S metrics modelers can generate for decision-makers is practically endless. Please see Table 5 for a list of recent M&S studies focused on producing meaningful metrics. Some of the types of M&S metrics found in the literature include speed profiles, distance metrics, economic metrics, circuit glitch reductions, body injuries, node degree, and average path length. According to Xiong et al. (2017), useful military M&S metrics can help decision-makers to make rational and scientific-based decisions. Practitioners implementing M&S for military organizations should verify that metrics will help decision-makers during the requirements gathering phase. Military decision-makers can make logical and science-based decisions when provided meaningful M&S metrics.

Table 5

Recent M&S Studies Focused on Producing Meaningful Metrics

Author/Date	Title
Bathla et al. (2019)	A simulation-based metric to guide glitch power reduction in digital circuits.
Capocchi et al. (2020)	Discrete-event simulation model generation based on activity metrics
Fujii et al. (2020)	Correlation analysis of organ doses determined by Monte Carlo simulation with dose metrics for patients undergoing chest-abdomen-pelvis CT examinations
Goda et al. (2019)	Rapid tsunami loss estimation using regional Inundation hazard metrics derived from stochastic tsunami simulation
Kim et al. (2020)	Monte Carlo method for estimating whole-body injury metrics from pedestrian impact simulation results
Lin et al. (2020)	What is the influence of landscape metric selection on the calibration of land-use/cover simulation models?
Simmonds et al. (2020)	Can robotic surgery VR-simulation metrics be used to devise a universal proficiency index that would allow comparisons for all users?

Similar to data requirements, the primary TAM2 construct connected to M&S metrics is output quality. Metrics are M&S data decision-makers use to inform critical decisions. Simulation models are decision-support tools meaning humans must interpret M&S results and make decisions (Gaetani et al., 2020). High-quality output is essential to decision-makers (Verma et al., 2018). Quality output data should be accurate, reliable, complete, and timely (Goh et al., 2017; Verma et al., 2018). Simulations always include approximations; therefore, it is essential for modelers to understand the output quality decision-makers need (Demoulin & Coussement, 2020) and that spending excessive M&S resources may not justify the improvement in output quality (Gaetani et al., 2020;

Vázquez-Poletti et al., 2017). Practitioners managing M&S implementations for military organizations should strive to produce high-quality metrics relevant to the decision-makers. Based on the core principles of TAM2, increasing the output quality of a simulation model should positively influence the perception of usefulness, leading to an increased intention to use M&S.

Theme 2: Incorporate Subject Matter Experts Throughout Implementation

The second major theme found in the data is the importance of incorporating Subject Matter Experts (SMEs) throughout implementation. The right SMEs can strengthen each phase of implementation, which leads to more accurate results and increased adoption by decision-makers. Ten of the interviewees and 10 of the supporting documents discussed incorporating SMEs during military M&S implementations (see Table 6).

Table 6

Incorporate SMEs Throughout Implementation

	Interviews		Documents	
	Count	References	Count	References
Incorporate SMEs Throughout Implementation	10	42	10	83

According to C3P2, a military M&S effort is guaranteed to fail if the right mix of SMEs are not included in the implementation. Multiple participants described a process of building an M&S team based on the SMEs needed to address the requirements. When describing the process of selecting SMEs, participant C1P3 stated:

> If we need to know how to fight a capability, we go to the warfighter; for technical data, we go to engineering experts, sometimes we even branch out and partner with academia and others. Whatever is required for the specific problem, we typically build a team of SMEs around.

Likewise, participant C1P1 stressed the importance of first understanding the requirements, then building a team of SMEs with the experience needed to address the requirements. Using the example of implementing a combat simulation, participant CIP1 described the first step of understanding the requirements followed by "putting a team together with the experience in each of the selected sub technical areas or tactical areas if you're working with military officers or noncommissioned officers who would help with the combat simulation." Participant C2P4 stressed the need to engage SMEs during the initial project planning, even before selecting individual M&S development tools. According to participant C2P4:

> Having operators involved is crucial. And not just operators, you've got to think about how logistics are done. If your model includes any sort of logistics you have to include the logisticians. You need to understand how that system really works and what the capabilities really are. You need to talk to the communications folks to understand how communications work. So I think it's really important to bring in the operators, logisticians, as well as key communication folks.

Over 80% of the supplemental documents confirmed the importance of SME involvement. Document C2D3 confirmed the importance of building M&S teams around key SMEs in the following:

> Putting a successful team together requires astute selection of personnel, team chemistry, and good leadership. You need to "recruit" members who have the necessary knowledge and skills, create an environment in which they can work together productively, and set and enforce team goals and standards. Consideration should be given to those with relevant experience, knowledge, and interest in the subject matter. These individuals are frequently referred to as subject matter experts (SMEs) and/or stakeholders.

The theme of incorporating SMEs at critical phases of implementation can be seen throughout the data. The phases of M&S implementation depending on SME involvement include (a) requirements gathering and project planning, (b) data selection and creation, (c) metrics design, and (d) verification and validation.

When formulating M&S requirements, C2P4 suggests working with SMEs to understand a particular weapons system and document how it operates and how it functions. Similarly, when describing M&S planning efforts, C1P3 stated, "Generally, we go to warfighters to help us with figuring out how to fight different capabilities. And so that's definitely a best practice." Likewise, multiple participants expressed the criticality of working with SMEs to understand, gather, and create the needed data to support the M&S effort. Participant C2P3 stated, "Usually we have a subject matter expert on that particular data on staff, or on the team working together to come up with the best suitable data for the project." Identically, C2P2 stated, "You would need someone on the team who is an expert on the type of data that you need in order to create a model." As further explanation, C2P2 added:

> For example, if somebody is telling you, *hey, you know, this facility is 5000 BSI*, and you talk to the data experts, they may say, *yeah, not in that country, that's not what they do there, it's probably 3000 BSI*. So that's the type of expertise I'm talking about when I say you need expertise in the type of data that you're gathering.

Document C2D3 described data certification as "the process of obtaining expert consensus that data are the best available data for specified uses." Similarly, document C2D1 advised practitioners to "ensure data has been vetted by an appropriate information owner for accuracy, fidelity, and currency." Subject matter expects are also needed when confirming the needed metrics. Instead of simply simulating one aircraft outperforming another, participant C2P4 suggested bringing in an operator to ask, "What does that really mean? What metrics are meaningful to you? And by using those inputs, you now have an idea of what I really want to measure." Formal Verification and Validation (V&V) was another critical step reported as needing the expertise of SMEs. In addition to five of the supporting documents, participants C1P1, C1P2, C1P3, C2P2, C2P4, C3P1, and C3P3 described conducting V&V with the help of SMEs. While most participants recommended using known SMEs for validation efforts, participant C1P2 recommended "hiring on trusted agent SME support who have experience with V&V."

Incorporating SMEs in M&S efforts is a theme reflected in scholarly research. According to Bryant et al. (2020), a multidisciplinary group consisting of SMEs and simulation experts are the best at developing realistic simulation scenarios. Verkuyl et al. (2018) included SMEs throughout the implementation process when developing a realistic clinical simulation. Verkuyl et al. (2018) consulted a team of SMEs during the

research, planning phases, and development by conducting usability tests where the SMEs' feedback was used to enhance the simulation. Similarly, when developing a Navy Hawk jet missile model, Stanton et al. (2019) conducted multiple working groups and interviews with various military and civilian SMEs throughout implementation, which resulted in enhancements that increased safety. According to Nikolic (2020), M&S experts should work with military SMEs who are authorized and qualified to describe real military systems and situations when developing conceptual models and performing validation.

In general, the literature demonstrates that validation is a phase of M&S implementation that benefits significantly from SME involvement. Some scholars believe the validation of simulations cannot be confirmed unless subject matter experts provide input (Patel et al., 2020). In addition to validating model logic and output (Rasoulkhani et al., 2020), SMEs can be used to validate any assumptions made to the model or data (Wang et al., 2019). The available scholarly literature documents the importance of incorporating SMEs throughout various phases of M&S implementation to include planning, development, testing, and validation. Practitioners implementing M&S technology for military organizations can develop more robust modeling scenarios, increase realism, validate assumptions, and increase overall model validity by incorporating SMEs.

The theme of incorporating SMEs is related to multiple constructs of TAM and TAM2. Because SMEs' inclusion can positively impact conceptual modeling, data creation, metrics selection, and validation, it stands to reason that SMEs can influence output quality. The more substantial influence found in the literature was the positive

influence SMEs can have on Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). When using TAM to investigate the implementation of simulation models in the healthcare arena, Verkuyl et al. (2018) found that including SMEs positively influenced PU and PEOU. The feedback provided by the SMEs can be used to directly enhance M&S usability (Verkuyl et al., 2018). Likewise, Rasoulkhani et al. (2020) noted that SMEs could evaluate the validity, quality, and usefulness of a model. When using SMEs to validate models and simulations, Patel et al. (2020) described the process as evaluating performance and confirming usefulness. Incorporating SMEs throughout the implementation process and acting on their feedback can lead to more useful and easier to use simulations and models. This concept is even more vital in military M&S efforts, where military SMEs are often the only experts authorized and qualified to adequately describe and validate real-world military systems.

Theme 3: Anticipate and Overcome Persistent Challenges

The third major theme is to anticipate and overcome persistent challenges. If practitioners who are implementing M&S technology for military organizations are aware of persistent challenges, mitigations can be formulated in advance. While using constructs from TAM2 to investigate simulation technologies, Sorko and Komar (2020) observed that "employees always strive for solutions that require little implementation effort" (p. 354). The goal of anticipating and overcoming persistent M&S challenges is to reduce implementation effort. Each interview transcript and supporting documents reported challenges in one or more of the three subthemes (see Table 7). The three subthemes for anticipating and overcoming persistent challenges include missing

interoperability standards, cumbersome DoD cybersecurity policies, and limitations and assumptions in M&S. Each of the subthemes will be presented in the following sections.

Table 7

Subthemes for Anticipate and Overcome Persistent Challenges

	Interviews		Documents	
Subtheme	Count	References	Count	References
Missing Interoperability Standards	6	29	10	93
Cumbersome DoD Cybersecurity Policies	8	24	5	39
Limitations and Assumptions in M&S	5	10	7	35

Subtheme: Missing DoD M&S Interoperability Standards

Across the military services, the lack of M&S interoperability standards at the DoD level is a significant challenge. Without mandated interoperability standards, the services will continue to struggle when attempting to establish federated M&S environments that link multiple simulation solutions together so they can exchange data and interoperate. Six of the interview transcripts and 10 of the organizational documents contained references to the subtheme. Document C2D1 defines interoperability as:

> The ability of systems, units, or forces to provide data, information, material, and services to, and accept the same from, other systems, units, or forces, and to use the data, information, materiel, and services exchanged to enable them to operate effectively together.

Participant C2P1 stated, “Within the DoD, we have problems with interoperability, meaning when we train with our service partners, we have issues being able to connect simulation capabilities to exchange and share data and information based on the training

objectives." Instead of relying on DoD interoperability standards, participant C2P1 described holding working groups between the services to document common practices and procedures. This approach is time-consuming but can lead to individual instances where a level of interoperability is achieved, but a significant degree of constant integration and testing is needed to maintain interoperability.

Similarly, participant C3P1 reported the lack of DoD interoperability standards for M&S as a significant challenge facing the services. Participant C3P1 noted that the DoD uses standards across the board for everything from fuel to ammunition, but "for some reason or another, we're having difficulty on the technical side of simulation to create interoperability standards that are readily available." While utilizing instruments like an interoperability roadmap, a shared strategic plan, or a Memorandum of Agreement (MoA) between the services can help, participant C3P1 noted:

> Although the services from my experience agree there should be standards, we just can't agree on which standards. So, until there is a top-down policy change provided by the DoD in the form of a directive or an instruction, that's DoDD or DoDI, then I think we're going to fumble this for quite some time longer.

While the call for a DoD level mandate on M&S interoperability was echoed in the interviews of C3P2 and C3P3, proprietary formats was identified as a root cause. Participant C3P2 stated that "Interoperability has always been a big issue, and the issue we have is proprietary systems." Later, C3P2 added, "The real issue is the output format because a lot of these systems are proprietary, so they're owned by private industry." The recommended fix C3P2 provided was a "higher level DoD policy directed at the procurement of future systems that would address some of the proprietary issues."

Participant C3P3 reported interoperability of simulations as “the biggest headache I have.” According to C3P3, “The DoD has a broad spectrum of contracts that we use, and every contractor has their own proprietary software. We have no way of getting all the simulations to talk to each other.” In the same dialogue, the interviewee added:

> We spent millions and millions of dollars to try to get these things to, you know, interact with one another. Not only simulations, but the simulators that we use. Everything has a different format, a different database. Sometimes they talk to each other, sometimes they don't. And then we have to find something to, you know, get these things to talk to each other.

Similar to C3P2, the recommended fix suggested by C3P3 was a DoD policy that would require all contractors to address interoperability by using open formats so the DoD could “find a means to get all these things that we've spent millions of dollars on to talk across the board because we don't have that right now.”

Out of the 10 supplemental documents that addressed interoperability challenges, many specifically mentioned proprietary systems calling for high-level policy changes. Document C2D1 described the DoD M&S landscape as a collection of “disparate and incompatible systems” that should be utilizing a common architecture, yet many “are extremely relevant but are contractor proprietary, driving significant sustainment bills every year.” According to document C2D1, the goal over the next 15 years is to develop and acquire interservice M&S systems that are open, nonproprietary, fully interoperable, and based on a common architecture. Likewise, document C2D4 reported interoperability between DoD simulations as a challenge because the systems were built using different standards. Document C2D4 confirmed that DoD M&S systems built using proprietary

formats are technically difficult to integrate and require significant time and specialized contract labor to do so. In addition to reporting a DoD wide interoperability problem between simulators, document C3D1 stated, “Until there is substantial interoperability between disparate simulation systems, the full benefit of simulation to the “fight and win” may not likely be realized.”

The importance and challenges associated with obtaining interoperability between M&S systems are well documented in the body of knowledge. Anagnostou and Taylor (2017) observed that simulating large-scale systems, which is more prevalent in the defense sector, often requires distributed simulation. One of the main barriers in distributed simulation is the technical complexity of implementing interoperability between simulations, which led to developing the well-known High-Level Architecture (HLA) standard (Anagnostou & Taylor, 2017). The U.S. Department of Defense (DoD) developed the HLA as an open framework to manage interoperability between distributed military simulations (Choi et al., 2018; Falcone & Garro, 2019; Gorecki et al., 2018). After the IEEE released the HLA standard as IEEE Std 1516-2010, the framework grew in popularity and is now a preferred interoperability standard in the military, industrial, and scientific communities (Falcone & Garro, 2019). The HLA promotes interoperability in a distributed simulation (federation) by defining specifications for a Run-Time Infrastructure (RTI) used to maintain synchronized communications between individual simulations (federates; Choi et al., 2018; Falcone & Garro, 2019; Gorecki et al., 2018). In a recent study funded by the U.S. Joint Staff, Reitz and Seavey (2018) found that the military services were satisfied with open interoperability standards like HLA, but DoD level policy was needed to enforce adoption and forbid proprietary vendor

implementations that violate the standards. According to Reitz and Seavey (2018), “we see top-down guidance from DoD and/or Joint Staff as the only way to ensure simulation interoperability in the U.S.” (p. 7). Practitioners implementing M&S solutions for military organizations should be aware of the lack of DoD policy regarding interoperability. Not only should popular open standards like HLA be integrated, but organizations should avoid proprietary middleware.

The core constructs of TAM2, which are Perceived Usefulness (PU) and Perceived Ease of Use (PEOU), have been used to examine the impact interoperability has on technology adoption. Costa et al. (2020) used the PU and PEOU constructs to investigate the challenges surrounding the incorporation of standard interoperability architecture in Model-Driven Development (MDD). Yang et al. (2017) confirmed the importance of interoperability on technology adoption and noted a positive influence on PU and PEOU. When developing a hybrid conceptual model for Building Information Modeling (BIM), Hilal et al. (2019) found that successful interoperability between BIM and other systems positively influences PU and PEOU. According to Shin and Jin Park (2017), interoperability can be a challenge, yet systems that incorporate open interoperability standards can more easily exchange data across organizational boundaries, which will have a positive influence on PEOU. Even though interoperability can be a challenge, M&S implementations that account for interoperability, especially when open standards are used, can increase PU and PEOU. Increased PU and PEOU positively influence intention to use, which leads to more successful technology adoptions.

Subtheme: Cumbersome DoD Cybersecurity Policies.

Another common challenge for M&S practitioners supporting military organizations is cumbersome DoD cybersecurity policies. Cybersecurity requirements can significantly delay implementations and prevent practitioners from sharing M&S technology and data with other organizations. Eighty percent of the participants discussed challenging cybersecurity policies, and five of the supporting documents touched on the subtheme as well. Some of the participants reported restrictions on individual M&S tools. Participant C1P1 stated, "there were sometimes restrictions on software that we were allowed to use because of, you know, DOD security restrictions." Likewise, C1P2 added, "After all, what good is a great tool if you cannot deploy it." Participant C3P2 reported the root cause as "The risk management framework process," which often leads to IT professionals losing the "ability to have administrative rights" that allow them to install needed software and debug issues as they come up. The National Institute of Standards and Technology (NIST) Risk Management Framework (RMF) was reported by multiple participants as an impediment to implementing M&S technology.

Participant C2P1 reported multiple challenges with the RMF process that requires "the development of a process for dealing with the legacy systems." When discussing RMF and legacy systems, participant C2P1 stated:

> Well, I think what is happening is our risk management framework; a lot of people are struggling with that across the government. When we migrated from an old process, we called DIACAP to this risk management framework, that, that caused major problems for us within the modeling and simulation community because there's a lot of legacy systems.

According to participant C2P1, legacy M&S systems that have not passed the RMF process “are not accredited to run on a DoD network.” Similar cybersecurity challenges were reported by interviewee C3P2, who stated, “An ongoing issue in the IT world, that is rather frustrating for most people in the M&S community is the cybersecurity ATO RMF piece, that is actually kind of creating barriers to effective M&S in the DoD.” In the context of DoD cybersecurity, ATO stands for authorization to operate. Participant C3P2 added:

> So hopefully, some of the issues can be addressed in regards to, number one, cybersecurity ATO risk management framework, which I think hinders a lot of organizations. Currently, the J6 cybersecurity community type guys are sometimes not viewed very friendly in the modeling and simulation community.

Similar frustrations with the DoD cybersecurity process was shared by participant C2P2, who mentioned that sometimes they could get M&S systems accredited for research and development purposes, but not operations. Even after a system was accredited, participant C2P2 stated:

> So it was a hurdle for us to get it accredited and get it onto the network, but once we, we, we get it accredited, once we get it, you know, we can use it for whatever a couple of years, I don't know, whatever the ATO says, but every time we do a new version, we have to go through all that pain, you know, to get an accreditation. And that is a pain in the butt.

Participants C2P2, C3P1, and C3P2 reported that the RMF process to obtain an ATO can take two years or more. The only strategy C3P2 had was to build excessive time into the schedule to accommodate the lengthy accreditation process. Document C3D3 confirmed

that the DoD process to accredit M&S environments is unacceptably long and takes months to complete instead of days. Furthermore, document C2D1 stated that "our ability to conduct integrated training has lagged due to security restrictions." Document C2D1 acknowledged that cybersecurity was more critical than ever, but cyber policies should not inhibit implementation. Some of the participants shared additional cybersecurity workarounds. Participant C2P4 observed that "The biggest challenge we have with modeling and simulation overall as an agency, is cybersecurity policies. It's extremely difficult to get modeling and simulations put onto a lot of our computers that are on the network." As a workaround, participant C2P4 added:

> What you have to do is run most of this stuff on a standalone network or machine. They are starting to clamp down to a point that it's become very cumbersome for us, and very difficult, and hard to overcome. And essentially how we overcome it, to be honest, we just ignore it. Yeah. So, we just, we just have to take a standalone network or machine and build it up and just not tell everybody. You know. It's crazy. It's insane that we have to do that.

According to C2P4, every military base in the participant branch of service that utilizes M&S has created a separate network as a workaround to overly restrictive cybersecurity policies, so models and simulations can still be developed. The strategy that helps C2P1 is working with one primary office in the military service that accredits IT systems. Additionally, when addressing RMF accreditation requirements, participant C2P1 stated, "What helps is when we get a whole team of contractors led by a government person who guides us through the RMF process, and then we make the ATO recommendation to the general officer." Practitioners seeking to implement M&S

technology for military organizations should be aware of the cybersecurity challenges found in the data. Additional time and resources may be needed to obtain an RMF ATO for a M&S system to be implemented on a DoD network.

The challenges and limitations of implementing standardized cybersecurity policies are a common theme found in the literature. While Brunner et al. (2020) acknowledged that security standards like the NIST RMF provide organizations with useful guidelines, the frameworks only provide general security requirements that depend on multiple stakeholders making complex and subjective decisions. According to Samonas et al. (2020), various cybersecurity stakeholders interpret security policies differently and often incorrectly because cybersecurity texts are often very long and not read by everyone. Compliance is improved when stakeholders have a common perception of the form, content, and process aspects of a cybersecurity policy (Samonas et al., 2020). Even proper implementation of compliance policies like those provided by NIST only provides minimum security assurances (Torkura et al., 2020) and often leads to a "compliance culture" that produces watered-down security defenses (Shin & Lowry, 2020). Risk management-based cybersecurity policies that focus on standardizing processes like security control compliance, patch management, and security training are insufficient at thwarting sophisticated cyberattacks (Shin & Lowry, 2020). According to Phillips et al. (2018), in addition to mandating RMF compliance, the DoD should assess relevant NIST resiliency standards designed to promote fault-tolerance security in the software development process. To apply standardized cybersecurity policies such as the NIST RMF, all cybersecurity stakeholders should share a common understanding of the cybersecurity policies. Proactive practitioners seeking to prepare for sophisticated

cyberattacks must be willing to overcome a compliancy mindset by researching and applying additional cybersecurity best practices that go beyond standardized frameworks.

The primary constructs of TAM2 used by scholarly researchers to investigate security policy implementation are Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). Hansen et al. (2018) noted that concerns and fears regarding information security compliance are barriers to technology adoption. Increased security protocols can also give consumers the perception that technology will be harder to use and not as useful (Hansen et al., 2018). Ismail and Islam (2020) researched implementing a cybersecurity framework and auditing tool in a cloud computing environment and found a positive correlation between PU, PEOU, and user acceptance. While investigating compliance cultures that form due to information security policies, Otieno et al. (2020) found that users are more likely to comply if they believe the policies will be easy to apply and not complicate their lives. Conversely, Pratimaratri et al. (2019) found PEOU to be insignificant when researching cybersecurity compliance in the medical field but did find a significant positive relationship between PU and compliance behavior. To increase compliance behavior towards cybersecurity policies, Pratimaratri et al. (2019) suggested organizations focus on increasing the employees' attitude and perceptions of usefulness. The perceptions of usefulness and ease of use can significantly impact attitudes towards adopting cybersecurity policies. Practitioners attempting to implement M&S technology for military organizations should be aware that some IT project managers perceive that the NIST risk management framework is not easy to use, which may negatively influence attitudes towards compliance. Streamlining the RMF process, improving the overall

attitude towards cybersecurity, and expounding on the security framework's usefulness may improve compliance behavior in the M&S community.

Subtheme: Limitations and Assumptions

An essential aspect of military M&S is properly documenting and communicating essential assumptions and limitations during implementation. Five of the interviewees and seven of the supporting documents referred to the subtheme. The DoD Instruction 5000.61, which establishes procedures for verification and validation of models, simulations, and distributed simulations, states that the summary of results should include M&S limitations and assumptions (DoD, 2018). Because M&S depends on abstraction, the "process of selecting the essential aspects of a simuland to be represented in a model or simulation" (DoD MSE, 2020, Terms and Definitions section A-B, para. 1), there will always be inherent assumptions and limitations. According to document C2D3, some M&S assumptions and limitations will not matter, while others could make the model unsuitable. Therefore, document C2D3 recommends understanding the implications to determine if the impact of the inherent assumptions and limitations is critical to the problem. Documents C1D1, C1D2, C1D4, C2D1, C2D3, and C2D4 provide multiple examples of documented M&S assumptions and limitations. An example of an assumption would be only modeling clear weather conditions (C2D3), while low levels of fidelity due to real-world sensor limitations of a weapon system represents an M&S limitation (C2D1).

To a large extent, the importance of understanding and divulging the inherent limitations and assumptions of a military M&S implementation stem from the critical

nature of the decisions being made. When discussing M&S limitations, participant C2P4 stated:

> So, there's got to be a lot of care when you're making very, very difficult decisions, very costly decisions, and you can't rely on the tool itself, not just M&S alone. The M&S tool should provide supporting evidence, but the tool should not be the answer provider because there is a large amount of uncertainty in the answer you put out. And so, the decision support must also reflect some notion of risk because of the limitations of the tool.

Participant C1P3 connected M&S assumptions and limitations to the decision-making process when stating, “and then obviously, given the intended use for M&S it's typically to inform something, there are also best practices associated with things like capturing limitations and or assumptions.” When assumptions are made because of a lack of knowledge, data, or maturity of the capability, participant C1P3 added, “we ensure that the decision-maker understands what assumptions we made about it, because we have a gap in our knowledge and we have to assume some things.” Similarly, participant C2P2 stated, “So you have to make some assumptions. You have to say, okay, this is the probability of success based on the battle damage assessment, but it’s very difficult to model battle damage assessment.”

A reported best practice for C1P2 was “Being upfront with the customer on the limitations of the modeling and simulation is also essential to managing expectations, see if that uncertainty is tolerable for their mission plans.” Similarly, participant C1P3 added:

> So, it's critically important that we understand the context for how we represent different things within our models. A lot of times, for decision-makers, we bring

> some of that context that helps drive specific outcomes in a big way, so it's important we discuss some assumptions that we make.

If there are concerns with the assumptions made, C1P3 stated that they could "go back and do a sensitivity analysis around the assumptions." Participant C2P2 mentioned "technology trust" several times and considered practitioners consider "how far are you willing to trust the output of the simulation considering the assumptions you made." Participant C2P4 noted that if you are simulating at an engineering level, based on first principles, "then you've got really good predictive power," but if you are modeling military operations, "there is so much uncertainty in those models because you are simulating human involvement." When assumptions and limitations negatively impact the fidelity of the M&S results, C2P4 suggested explaining the uncertainty to the decision-maker and "bringing in SMEs to kind of provide some concurrence with what the M&S tool is saying."

Strategies for managing assumptions and limitations in modeling and simulation are present in the body of knowledge. Vanbrabant et al. (2019) noted that insufficient detail or data in M&S necessitates the use of more simplifying assumptions, which impairs the validity of the results and produces higher levels of abstraction. Complex models that contain submodels of subsystems often require uncertainty management when expert modelers are needed to make substitutions of unknown operators or data elements (Kovalchuk et al., 2018). According to Wang et al. (2019), all key assumptions, including assumptions in the data, should be documented, reviewed, and validated by subject matter experts. A best practice reported by Erdemir et al. (2020) is to communicate limitations and assumptions to the decision-maker during M&S

development, which establishes inherent "buy-in" (p. 3). A preferred technique for communicating assumptions and limitations is clearly describing the real-world system's obtained abstraction level under investigation (Erdemir et al., 2020). The importance of the subtheme can be seen in that many authors now include dedicated sections for assumptions and limitations in scholarly M&S articles (Chen et al., 2021; Grzybowska et al., 2020; Liu et al., 2019; Peitso & Brutzman, 2020). Practitioners managing elaborate military M&S efforts should document assumptions and limitations that could impact the results. Subject matter experts should validate critical assumptions and help communicate all documented assumptions and limitations to the decision-makers.

While TAM2 as a technology adoption model does not appear to have been used to study M&S assumptions and limitations directly, constructs of the framework have been used to investigate M&S abstraction and fidelity considerations. Shao et al. (2017) used the Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) constructs to evaluate stakeholder adoption of modeling methodologies and found one model was preferred based on lower levels of abstraction. In a study conducted by Nicolaides et al. (2020), the authors examined the perceived usefulness of medical training simulations and found higher fidelity levels were more realistic and promoted superior leadership in students, but higher levels of fidelity also produced higher levels of stress. Similarly, Padilha et al. (2018) found that even though high-fidelity medical simulators have grown in popularity for training purposes, pregraduate nursing students rated clinical virtual simulators higher based on PU and PEOU. When managing M&S implantations, IT project managers should be aware that abstraction and fidelity can influence perceived

usefulness and perceived ease of use. Military M&S practitioners may be able to increase adoption by decreasing abstraction and providing high-fidelity results.

Applications to Professional Practice

Information technology project managers who follow the strategies uncovered in this study should be able to experience smoother M&S implementations, anticipate and overcome persistent challenges, and increase technology adoption. Smoother M&S implementations start with truly understanding the requirements. In addition to understanding the real-world systems to be emulated, practitioners need to capture the context and understand the problem under investigation. Once the general M&S requirements have been captured, practitioners must understand the corresponding data requirements. Military models and simulations are big data consumers, and the adage "garbage in, garbage out" applies. To produce high-quality results, project managers must obtain high-quality data from authoritative sources. The general M&S requirements, coupled with the complementary data sources, should be used to produce meaningful metrics. The overall objective of military M&S is to inform a decision; therefore, the needed metrics must be understood during the requirements gathering stage. Not only can subject matter experts help refine the requirements, but they can also be used to strengthen each phase of implementation. The success of military M&S efforts could depend on IT project managers recruiting the right mix of authorized SMEs who possess the unique knowledge, skills, and abilities needed to support the project.

Anticipating and overcoming persistent challenges can help improve the practice of modeling and simulation in multiple ways. Long-standing interoperability challenges are preventing the services from smoothly connecting simulators to exchange data and

execute joint training exercises. Until there is a DoD level policy mandating the use of specific open interoperability standards and forbidding the use of proprietary vendor modules, IT project managers can proactively address these considerations one project at a time. Memorandums of agreement can be used to get the services to adopt a common open interoperability standard like the HLA and avoid proprietary vendor formats that prevent interoperability and drive up sustainment costs. Practitioners should also be aware that the RMF process can take a year or more to accredit M&S implementations for use on a DoD network. Strategies such as scheduling adequate time to address RMF requirements and utilizing specialized RMF compliance teams can streamline and expedite the process. The ultimate goal should be to change the compliance culture by promoting a common understanding of the RMF implementation process and the benefits of a firm cybersecurity policy. Lastly, project managers should be aware that all M&S implementations will include limitations and assumptions that could influence the results. Practitioners can reduce the risk associated with assumptions and limitations by (a) using subject matter experts to validate documented assumptions, (b) keeping decision-makers informed of all key assumptions and limitations, and (c) performing a sensitivity analysis when there are concerns.

Examining each strategy through the lens of TAM2 provided additional insight relevant to the practice of IT. When gathering M&S requirements, practitioners should be considering how to deliver the requested functionality in easy to use features that enhance job performance. Incorporating subject matter experts throughout the implementation process can help achieve this goal while simultaneously increasing the intent to use the final M&S tool. Considering how important data is to successful M&S, technologists

should know that high-quality input data can increase the perception of usefulness. Likewise, high-fidelity output and the quality of the final M&S metrics can increase a decision-maker's perception of usefulness, leading to an increased intent to use M&S technology in the future. Modeling and simulation professionals who incorporate open interoperability standards and decrease abstraction levels can increase both perceived usefulness and perceived ease of use at the same time. Understanding where there are negative perceptions towards IT can also help improve the practice. In the military M&S domain, some IT professionals have the perception that the NIST risk management framework is not easy to use and struggle to see the usefulness. Explaining the RMF process and the usefulness of a firm cybersecurity policy to all stakeholders may improve the attitude towards the RMF in the M&S community. Overall, the extended TAM model provided significant insight from a technology acceptance point of view.

Implications for Social Change

More successful M&S implementations can lead to positive social change in several ways. At the core of successful M&S is the increased safety aspect of the discipline. If military decision-makers can make informed science-based decisions because of accurate, high-fidelity results and meaningful metrics, lives can be saved. The wide range of M&S benefits includes increased safety, protection, preparedness, defense, efficiencies, financial savings, and scientific discoveries. If practitioners can use the provided strategies to increase interoperability, the immediate and tangible benefits include exchanging data and collaborating on jointly distributed simulations. For military organizations, successful interoperability will immediately drive down sustainment costs and enable more realistic training scenarios for the warfighter.

Another group of strategies with the accompanying benefits can lead to increased confidence in M&S as a viable tool for decision making. The challenges uncovered during this study have negatively impacted the credibility of M&S for some senior leaders in the military. Helping practitioners anticipate and overcome persistent M&S challenges can increase the success rate, improve security, shorten development schedules, and produce cost savings. Each of these tangible benefits will strengthen confidence in M&S. Senior leaders in the military often seek out trusted subject matter experts' advice. Incorporating SMEs known by the decision-makers further strengthens the validity of the results and increases decision-maker confidence. A multidisciplinary group of SMEs generates a diversity of thought and capitalizes on the strengths of individuals.

There are additional long-term benefits that could be created through the implementation of M&S strategies that increase success. Considering the current political climate and financial footing in the United States, a safer, more informed military seeking to be better stewards of the taxpayer’s money can generate positive change in individuals and society. When military and private organizations can save money on IT projects, the surplus of funds is repurposed for other valuable efforts needing additional funding. Furthermore, many military M&S efforts are used to uncover and reduce risk to civilian populations living within the vicinity of military bases or ongoing military operations. Sharing these M&S benefits with various governments and agencies, foreign and domestic, can foster goodwill and strengthen civil-military relations.

Recommendations for Action

Various stakeholders, including M&S practitioners, IT project managers, and decision-makers, should investigate the applicability of this qualitative multiple-case study's findings. Relevant strategies could be distributed or discussed in the various military communique as well as ongoing M&S conferences and working groups. Multiple strategies should be addressed upfront in the project planning and requirements gathering phases. When creating a project schedule, practitioners should create milestones and relevant tasks associated with capturing the general M&S requirements, the associated data requirements, and the needed metrics. Subject matter experts should be identified and recruited during these initial phases. Subject matter experts can help refine and validate all the M&S requirements, especially the data's authenticity. Additional tasks should be added to explicitly confirm the team's understanding of the needed metrics with the decision-makers. Practitioners who are intentional with applying these M&S strategies during the early stages of implementation will set their team up for success.

Cybersecurity and interoperability requirements should be considered upfront rather than later in the project. The risk management process is well-defined in military cybersecurity offices. Managers who initiate a military M&S project should consult with the cybersecurity organization responsible for accrediting the M&S system to be used on a DoD network. Cybersecurity departments can provide a standard Plan of Actions and Milestones (POAM) for the RMF process. Once the scope of the M&S project is known, a military cybersecurity department can advise whether a specialized team is needed to assist with the RMF process. Milestones from an RMF POAM should be added to the M&S project schedule and monitored accordingly. Depending on the nature of the model

or simulation, interoperability may be an additional consideration. If the team determines the final M&S tool or system can be connected to another M&S system, project managers must include scheduled tasks for addressing interoperability. The Program Management Offices (PMO) for each M&S system to be interconnected should be contacted early so that that project managers can coordinate technical exchange meetings. If open interoperability standards such as the HLA can be agreed upon, memorandums of agreement should be created and signed by the PMOs. Additional tasks will be needed throughout the project for developing and testing the performance of data exchange interfaces.

Properly addressing M&S assumptions and limitations will also increase the results' accuracy and help manage decision-makers' expectations. When modelers make assumptions and the team identifies limitations, project managers should document both appropriately. Assumptions and limitations should be validated by SMEs and reviewed by decision-makers throughout the project. Addressing assumptions and limitations in this way creates transparency and inherent buy-in by the decision-makers. Project managers should intentionally ask the decision-makers if there are questions or concerns about the assumptions and limitations and offer a sensitivity analysis when needed. The very nature of M&S ensures assumptions and limitations will always be present, yet proper management of both will help manage risk and expectations. Explicitly managing and communicating the assumptions and limitations of M&S will reinforce the idea that M&S technology should only be used to inform decisions, not provide answers outright.

Recommendations for Further Study

This qualitative multiple-case study was designed to gather M&S implementation strategies from civil servants supporting military organizations. Qualitative researchers seeking to extend the research could consider conducting an ethnographic study. An ethnographic design would require the researcher to conduct extended observations of military M&S practitioners in the field. Ethnography may shed more light on the unique process of gathering military M&S requirements and incorporating specialized subject matter experts throughout a complex M&S project. In more than one interview, the participants used the word pedigree to describe M&S experts who were trusted in the community, indicating a possible correlation to military M&S culture or training. The data also indicated that large-scale military M&S often depends on big-data, commonly referred to as big-simulation. Researchers could adapt prior studies on big-data to investigate big-simulation efforts being conducted by the military. Another recommendation for future researchers would be to use the descriptive qualitative results of this study to inform a quantitative investigation designed to query a larger population and sample of modeling and simulation stakeholders. In addition to applying structured data analysis techniques, future researchers can more easily reproduce quantitative studies.

Separate studies could be used to research the reported challenges associated with RMF and interoperability. While there is a large body of research connected to cybersecurity policy adoption, my literature review did not uncover studies designed to investigate cybersecurity policy adoption in the M&S domain. Likewise, scholarly research has been conducted to investigate the negative aspects of fostering a

cybersecurity compliance culture, but not specifically in modeling and simulation organizations. The data indicated a negative perception of cybersecurity and the RMF process in the military M&S community, which warrants additional research. When addressing interoperability challenges, the participants did provide workarounds and expressed the need for a mandated DoD policy requiring the use of open interoperability standards. Additional research of military M&S interoperability challenges could consider software vendors' views and opinions reported using proprietary interoperability standards. Investigating the software vendor's point of view may provide additional insight into the benefits and challenges of mandating the use of open M&S interoperability frameworks.

Reflections

When I started my doctoral journey, I became interested in using modern 3D game engines to develop interactive modeling and simulation tools for my military organization. However, I was hesitant based on my lack of experience managing modeling and simulation projects. With nearly 25 years of experience as an IT practitioner supporting military organizations, personal bias or preconceived ideas on how best to implement IT was something I had to acknowledge and control while conducting my research. Documenting my ideas in field notes, administering open-ended questions that truly allowed the participants to explore their own thoughts and opinions, member checking sessions, and my mentor's oversight helped limit the personal impact bias on research findings. By the end of my study, I was pleasantly surprised where my participants had taken us. The strategies uncovered were their own, and I was honored to have been a part of the process.

Even though I knew none of the interviewees before my study started, by the end, I felt like I had earned the trust of each participant. When making the first contact, some participants were hesitant on whether they had the knowledge or experience needed to contribute to the research topic. By the end of each interview, it was clear that the participant was the subject matter expert, and I was there to learn. Every interview shed more light on the phenomenon and expanded my understanding of what it took to successfully implement models and simulations for military organizations. Some participants' initial reservations may have had towards me as an outsider inevitably fell away before the interview was over. By the time I asked if there was anything else they wanted to add, many were treating me as a confidant. More than one participant asked me in their closing remarks to help them address specific challenges or spread best practices as I move forward in my research and career. Armed with what I learned during my study, I am confident I am better prepared as an IT project manager to guide successful M&S implementation.

Summary and Study Conclusions

My primary research objective was to uncover M&S implementation strategies IT project managers used to support military organizations. Scholarly research on the topic is rare, and most military studies neglect to include essential details and best practices. My findings included three major and six minor themes that can be applied as implementation strategies by practitioners supporting military organizations. The major themes focus on the importance of understanding the true M&S requirements, incorporating vital subject matter experts, and anticipating and overcoming persistent challenges. Diverse organizations, individuals, and academia can also use the best

practices and recommendations to improve IT practice, elicit positive social change, and continue scholarly research on the topic. Information technology project managers supporting military organizations, who follow the presented strategies, will be better equipped to manage complex, multifaceted modeling and simulation projects.

References

Abar, S., Theodoropoulos, G. K., Lemarinier, P., & O'Hare, G. M. (2017). Agent-based modeling and simulation tools: A review of the state-of-art software. *Computer Science Review*, *24*, 13-33. https://doi.org/10.1016/j.cosrev.2017.03.001

Abas Sunarya, P., Sudaryono, & Utami, W. S. (2020). Implementation of aircraft productivity system to improve company performance. *Journal of Physics: Conference Series*, *1477*, 022025. https://doi.org/10.1088/1742-6596/1477/2/022025

Abdelmegid, M., González, V., O'Sullivan, M., Walker, C., Poshdar, M., & Ying, F. (2020). The roles of conceptual modeling in improving construction simulation studies: A comprehensive review. *Advanced Engineering Informatics*, *46*. https://doi.org/10.1016/j.aei.2020.101175

Ackerman, S., Gleason, N., & Gonzales, R. (2015). Using rapid ethnography to support the design and implementation of health information technologies. *Techno-Anthropology in Health Informatics*, *215*, 14-27. https://doi.org/10.3233/978-1-61499-560-9-14

Alefari, M., Barahona, A. M., & Salonitis, K. (2018). Modeling manufacturing employees' performance based on a system dynamics approach. *Procedia CIRP*, *72*, 438-443. https://doi.org/10.1016/j.procir.2018.03.161

Alessandrini, M., De Craene, M., Bernard, O., Giffard-Roisin, S., Allain, P., Waechter-Stehle, I., Weese, J., Saloux, E., Delingette, H., Sermesant, M., & D'hooge, J. (2015). A pipeline for the generation of realistic 3D synthetic Echocardiographic

sequences: Methodology and open-access database. *IEEE Transactions on Medical Imaging*, 34(7), 1436-1451. https://doi.org/10.1109/tmi.2015.2396632

Alice, R., Giuditta, P., & Cavalieri, S. (2018). Quantitative assessment of service delivery process: application of hybrid simulation modeling. *IFAC-PapersOnLine*, *51*(11), 1113-1118. https://doi.org/10.1016/j.ifacol.2018.08.454

Alkhuraiji, A., Liu, S., Oderanti, F. O., & Megicks, P. (2016). New structured knowledge network for strategic decision-making in IT innovative and implementable projects. *Journal of Business Research*, *69*(5), 1534-1538. https://doi.org/10.1016/j.jbusres.2015.10.012

Alpi, K. M., & Evans, J. J. (2019). Distinguishing case study as a research method from case reports as a publication type. *Journal of the Medical Library Association*, *107*(1). https://doi.org/10.5195/jmla.2019.615

Amaran, S., Sahinidis, N., Sharda, B., & Bury, S. (2016). Simulation optimization: A review of algorithms and applications. *Annals of Operations Research*, *240*(1), 351-380. https://doi.org/10.1007/s10479-015-2019-x

Amiri, R., Heidari, A., Dehghan-Nayeri, N., Vedadhir, A. A., & Kareshki, H. (2016). Challenges of transcultural caring among health workers in Mashhad-Iran: A qualitative study. *Global Journal of Health Science*, *8*(7), 203-211. https://doi.org/10.5539/gjhs.v8n7p203

Anagnostou, A., & Taylor, S. J. (2017). A distributed simulation methodological framework for OR/MS applications. *Simulation Modelling Practice and Theory*, *70*, 101-119. https://doi.org/10.1016/j.simpat.2016.10.007

Ando, H., Cousins, R., & Young, C. (2014). Achieving saturation in thematic analysis: Development and refinement of a codebook. *Comprehensive Psychology*, *3*. https://doi.org/10.2466/03.cp.3.4

Angelopoulou, A., Mykoniatis, K., & Karwowski, W. (2015). A framework for simulation-based task analysis - The development of a universal task analysis simulation model. *2015 IEEE International Multi-Disciplinary Conference on Cognitive Methods in Situation Awareness and Decision*. https://doi.org/10.1109/cogsima.2015.7108178

Anwar, S. R., Vandenberghe, W. G., Bersuker, G., Veksler, D., Verzellesi, G., Morassi, L., Galatage, R. V., Jha, S., Buie, C., Barton, A. T., Vogel, E. M., & Hinkle, C. L. (2017). Comprehensive capacitance–voltage simulation and extraction tool including quantum effects for high- k on SixGe1−x and InxGa1−xAs: Part II—Fits and extraction from experimental data. *IEEE Transactions on Electron Devices*, *64*(9), 3794-3801. https://doi.org/10.1109/ted.2017.2725741

Arbez, G., & Birta, L. G. (2016). A tutorial on ABCmod: An activity-based discrete event conceptual modeling framework. *2016 Winter Simulation Conference (WSC)*. https://doi.org/10.1109/wsc.2016.7822082

Argent, R. M., Sojda, R. S., Giupponi, C., McIntosh, B., Voinov, A. A., & Maier, H. R. (2016). Best practices for conceptual modeling in environmental planning and management. *Environmental Modelling & Software*, *80*, 113-121. https://doi.org/10.1016/j.envsoft.2016.02.023

Asampana, I., Akanferi, A., & Ami-Narh, J. (2017). Reasons for poor acceptance of web-based learning using an LMS and VLE in Ghana. *Interdisciplinary Journal of*

Information, Knowledge, and Management, *12*, 189-208. https://doi.org/10.28945/3742

Asare, A., Brashear-Alejandro, T., & Kang, J. (2016). B2B technology adoption in customer-driven supply chains. *Journal of Business & Industrial Marketing*, *31*(1), 1-12. https://doi.org/10.1108/jbim-02-2015-0022

Attia, M., & Edge, J. (2017). Be(com)ing a reflexive researcher: a developmental approach to research methodology. *Open Review of Educational Research*, *4*(1), 33-45. https://doi.org/10.1080/23265507.2017.1300068

Bapuuroh, C. B. (2017). Exhibiting resistance during an organizational transformation: The telecommunication industry in Ghana. *The Qualitative Report*, *22*(7), 1809-1829. http://nsuworks.nova.edu/tqr/vol22/iss7/6

Barajas, A., Alvarez, F., Munoz, J., Santaolaya, R., Collazos, C., & Hurtado, J. (2016). Verification and validation model for short serious game production. *IEEE Latin America Transactions, 14*(4), 2007-2012. https://doi.org/10.1109/tla.2016.7483547

Barbosa, C., & Azevedo, A. (2017). Hybrid simulation for complex manufacturing value-chain environments. *Procedia Manufacturing*, *11*, 1404 - 1412. https://doi.org/10.1016/j.promfg.2017.07.270

Barbosa, C., & Azevedo, A. (2018). Towards a hybrid multi-dimensional simulation approach for performance assessment of MTO and ETO manufacturing environments. *Procedia Manufacturing*, *17*, 852-859. https://doi.org/10.1016/j.promfg.2018.10.137

Baskerville, R. L., & Myers, M. D. (2015). Design ethnography in information systems. *Information Systems Journal*, *25*(1), 23-46. https://doi.org/10.1111/isj.12055

Bathla, S., Rao, R. M., & Chandrachoodan, N. (2019). A simulation-based metric to guide glitch power reduction in digital circuits. *IEEE Transactions on Very Large Scale Integration (VLSI) Systems*, *27*(2), 376-386. https://doi.org/10.1109/tvlsi.2018.2876917

Bayram, N., & Akın Ateş, M. (2020). The determinants of business analytics adoption: Does one-size fit all. *Journal of Business Research - Turk*, *12*(1), 583-598. https://doi.org/10.20491/isarder.2020.864

Beg, O., Abbas, H., Johnson, T., & Davoudi, A. (2017). Model validation of PWM DC-DC converters. *IEEE Transactions on Industrial Electronics*, *64*(9), 7049 - 7059. https://doi.org/10.1109/TIE.2017.2688961

Bengtsson, M. (2016). How to plan and perform a qualitative study using content analysis. *NursingPlus Open*, *2*, 8-14. https://doi.org/10.1016/j.npls.2016.01.001

Berger, D. H. (2019). *38th Commandant's planning guidance* (1907265). Headquarters Marine Corps, SSIC 05000 General Admin & Management. https://www.marines.mil/News/Publications/MCPEL/Electronic-Library-Display/Article/1907265/38th-commandants-planning-guidance-cpg/

Blaikie, N. (2018). Confounding issues related to determining sample size in qualitative research. *International Journal of Social Research Methodology*, *21*(5), 635-641. https://doi.org/10.1080/13645579.2018.1454644

Bokrantz, J., Skoogh, A., Lämkull, D., Hanna, A., & Perera, T. (2017). Data quality problems in discrete event simulation of manufacturing operations. *SIMULATION*, *94*(11), 1009-1025. https://doi.org/10.1177/0037549717742954

Brailsford, S. C., Eldabi, T., Kunc, M., Mustafee, N., & Osorio, A. F. (2018). Hybrid simulation modeling in operational research: A state-of-the-art review. *European Journal of Operational Research*. https://doi.org/10.1016/j.ejor.2018.10.025

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Braun, V., & Clarke, V. (2019). To saturate or not to saturate? Questioning data saturation as a useful concept for thematic analysis and sample-size rationales. *Qualitative Research in Sport, Exercise and Health*, 1-16. https://doi.org/10.1080/2159676x.2019.1704846

Brunner, M., Sauerwein, C., Felderer, M., & Breu, R. (2020). Risk management practices in information security: Exploring the status quo in the DACH region. *Computers & Security*, *92*, 101776. https://doi.org/10.1016/j.cose.2020.101776

Bryant, K., Aebersold, M. L., Jeffries, P. R., & Kardong-Edgren, S. (2020). Innovations in simulation: Nursing leaders' exchange of best practices. *Clinical Simulation in Nursing*, *41*, 33-40. https://doi.org/10.1016/j.ecns.2019.09.002

Buijs, M., & Spruit, M. (2017). Asynchronous social search as a single point of access to information. *Library Hi Tech*, *35*(4), 649-664. https://doi.org/10.1108/lht-01-2017-0007

Busse, C., Kach, A. P., & Wagner, S. M. (2016). Boundary conditions: What they are, how to explore them, why we need them, and when to consider them. *Organizational Research Methods*, *20*(4), 574-609. https://doi.org/10.1177/1094428116641191

Capocchi, L., Santucci, J. F., Pawletta, T., Folkerts, H., & Zeigler, B. P. (2020). Discrete-event simulation model generation based on activity metrics. *Simulation Modelling Practice and Theory*, *103*. https://doi.org/10.1016/j.simpat.2020.102122

Chaawa, M., Thabet, I., Hanachi, C., & Ben Said, L. (2017). Modeling and simulating a crisis management system: An organizational perspective. *Enterprise Information Systems*, *11*(4), 534–550. https://doi.org/10.1080/17517575.2016.1212275

Chanpuypetch, W., & Kritchanchai, D. (2018). A process reference model for the hospital supply chain of pharmaceutical products. *Industrial Engineering & Management Systems*, *17*(1), 43-61. https://doi.org/10.7232/iems.2018.17.1.043

Chauhan, S., & Jaiswal, M. (2017). A meta-analysis of e-health applications acceptance: Moderating impact of user types and e-health application types. *Journal of Enterprise Information Management, 30*(2), 295-319. https://doi.org/10.1108/jeim-08-2015-0078

Chen, J. C., Chen, T., & Teng, Y. (2021). Meta-model based simulation optimization for automated guided vehicle system under different charging mechanisms. *Simulation Modelling Practice and Theory*, *106*, 102208. https://doi.org/10.1016/j.simpat.2020.102208

Chen, Y., Wu, X., Bu, X., & Bai, R. (2015). EMMD-Prony approach for dynamic validation of simulation models. *Journal of Systems Engineering and Electronics*, *26*(1), 172-181. https://doi.org/10.1109/jsee.2015.00022

Chirumalla, K., Oghazi, P., & Parida, V. (2018). Social media engagement strategy: Investigation of marketing and r&d interfaces in manufacturing industry. *Industrial Marketing Management*, *74*, 138-149. https://doi.org/10.1016/j.indmarman.2017.10.001

Choi, M., Starbuck, R., Lee, S., Hwang, S., Lee, S., Park, M., & Lee, H. (2018). Distributed and interoperable simulation for comprehensive disaster response management in facilities. *Automation in Construction*, *93*, 12-21. https://doi.org/10.1016/j.autcon.2018.05.007

Chung, N., Han, H., & Joun, Y. (2015). Tourists' intention to visit a destination: The role of augmented reality (AR) application for a heritage site. *Computers in Human Behavior*, *50*, 588-599. https://doi.org/10.1016/j.chb.2015.02.068

Cigdem, H., & Oncu, S. (2015). E-assessment adaptation at a military vocational college: Student perceptions. *Eurasia Journal of Mathematics, Science & Technology Education*, *11*(5), 971-988. https://doi.org/10.12973/eurasia.2015.1368a

Cigdem, H., Ozturk, M., & Topcu, A. (2016). Vocational college students' acceptance of web-based summative listening comprehension test in an EFL course. *Computers in Human Behavior*, *61*, 522-531. https://doi.org/10.1016/j.chb.2016.03.070

Cigdem, H., & Topcu, A. (2015). Predictors of instructors' behavioral intention to use a learning management system: A Turkish vocational college example. *Computers in Human Behavior*, *52*, 22-28. https://doi.org/10.1016/j.chb.2015.05.049

Clapp, J. T., Gleason, K. A., & Joffe, S. (2017). Justification and authority in institutional review board decision letters. *Social Science & Medicine*, *194*, 25-33. https://doi.org/10.1016/j.socscimed.2017.10.013

Connelly, L. M. (2016). Trustworthiness in qualitative research. *Medsurg Nursing*, *25*(6). https://search.proquest.com/

Constantinou, C. S., Georgiou, M., & Perdikogianni, M. (2017). A comparative method for themes saturation (CoMeTS) in qualitative interviews. *Qualitative Research*, *17*(5), 571-588. https://doi.org/10.1177/1468794116686650

Costa, B., Pires, P. F., & Delicato, F. C. (2020). Towards the adoption of OMG standards in the development of SOA-based IoT systems. *Journal of Systems and Software*, *169*, 110720. https://doi.org/10.1016/j.jss.2020.110720

Costa, M. F., Costa, C. E., Angelo, C. F., & Moraes, W. F. (2018). Perceived competitive advantage of soccer clubs: a study based on the resource-based view. *RAUSP Management Journal*, *53*(1), 23-34. https://doi.org/10.1016/j.rauspm.2016.08.001

Courtenay, M., Lim, R., Castro-Sanchez, E., Deslandes, R., Hodson, K., Morris, G., Reeves, S., Weiss, M., Ashiru-Oredope, D., Bain, H., Black, A., Bosanquet, J., Cockburn, A., Duggan, C., Fitzpatrick, M., Gallagher, R., Grant, D., McEwen, J., Reid, N., … White, P. (2018). Development of consensus-based national antimicrobial stewardship competencies for UK undergraduate healthcare professional education. *Journal of Hospital Infection*, *100*(3), 245-256. https://doi.org/10.1016/j.jhin.2018.06.022

Cowdean, S., Whitby, P., Bradley, L., & McGowan, P. (2019). Entrepreneurial learning in practice: The impact of knowledge transfer. *Industry and Higher Education*, *33*(1), 30-41. https://doi.org/10.1177/0950422218812630

Cruz, A. M., & Haugan, G. L. (2019). Determinants of maintenance performance: A resource-based view and agency theory approach. *Journal of Engineering and Technology Management*, *51*, 33-47. https://doi.org/10.1016/j.jengtecman.2019.03.001

Cucurull-Sanchez, L., Chappell, M. J., Chelliah, V., Amy Cheung, S. Y., Derks, G., Penney, M., Phipps, A., Malik-Sheriff, R. S., Timmis, J., Tindall, M. J., Graaf, P. H., Vicini, P., & Yates, J. W. (2019). Best practices to maximize the use and reuse of quantitative and systems pharmacology models: Recommendations from the United Kingdom quantitative and systems pharmacology network. *CPT: Pharmacometrics & Systems Pharmacology*, *8*(5), 259-272. https://doi.org/10.1002/psp4.12381

Dadzis, K., Bönisch, P., Sylla, L., & Richter, T. (2017). Validation, verification, and benchmarking of crystal growth simulations. *Journal of Crystal Growth*, *474*, 171-177. https://doi.org/10.1016/j.jcrysgro.2016.12.091

Dahabreh, I., Balk, E., Wong, J., & Trikalinos, T. (2015). Guidance for the conduct and reporting of modeling and simulation in the context of health technology assessment. *Value in Health*, *18*(3), A7. https://doi.org/10.1016/j.jval.2015.03.045

Dai, N. T., Free, C., & Gendron, Y. (2019). Interview-based research in accounting 2000–2014: Informal norms, translation and vibrancy. *Management Accounting Research, 42*, 26-38. https://doi.org/10.1016/j.mar.2018.06.002

Davidson, J. B., Graham, R. B., Beck, S., Marler, R. T., & Fischer, S. L. (2021). Improving human-in-the-loop simulation to optimize soldier-systems integration. *Applied Ergonomics*, *90*. https://doi.org/10.1016/j.apergo.2020.103267

Davies, A., & Christie, N. (2017). An exploratory study of the experiences of wheelchair users as aircraft passengers – implications for policy and practice. *IATSS Research*, *41*(2), 89-93. https://doi.org/10.1016/j.iatssr.2017.05.003

Davis, F. D. (1986). *A technology acceptance model for empirically testing new end-user information systems : theory and results* [Doctoral dissertation]. https://dspace.mit.edu/handle/1721.1/15192

DeJonckheere, M., & Vaughn, L. (2019). Semistructured interviewing in primary care research: A balance of relationship and rigour. *Family Medicine and Community Health*, *7*(2). https://doi.org/10.1136/fmch-2018-000057

Demoulin, N. T., & Coussement, K. (2020). Acceptance of text-mining systems: The signaling role of information quality. *Information & Management*, *57*(1), 103120. https://doi.org/10.1016/j.im.2018.10.006

Dillworth, J., Dickson, V. V., Reyentovich, A., & Shedlin, M. G. (2019). Patient decision-making regarding left ventricular assist devices : A multiple case study. Intensive and *Critical Care Nursing*, *51*, 7-14. https://doi.org/10.1016/j.iccn.2018.10.004

DoD. (2018). *DoDI 5000.61* (5000.61). DoD Directives Division. https://www.esd.whs.mil/Directives/issuances/dodi/

DoD MSE. (2020). *DoD M&S glossary*. DoD Modeling and Simulation Enterprise. https://www.msco.mil/MSReferences/Glossary/MSGlossary.aspx

Eaton, J., Kalnins, R., McKearn, M., Wilson, P., & Zecha, A. (2014). Verification and validation of the Infantry Warrior Simulation (IWARS) through engagement effectiveness modeling and statistical analysis. *2014 Systems and Information Engineering Design Symposium (SIEDS)*. https://doi.org/10.1109/sieds.2014.6829874

Eisele, A., Schagg, D., & Göhner, W. (2020). Exercise promotion in physiotherapy: A qualitative study providing insights into German physiotherapists' practices and experiences. *Musculoskeletal Science and Practice*, *45*. https://doi.org/10.1016/j.msksp.2019.102104

Ellis, T., & Levy, Y. (2009). Towards a guide for novice researchers on research methodology: Review and proposed methods. *Issues in Informing Science and Information Technology*, *6*, 323-337. https://doi.org/10.28945/1062

Erdemir, A., Mulugeta, L., Ku, J. P., Drach, A., Horner, M., Morrison, T. M., Peng, G. C., Vadigepalli, R., Lytton, W. W., & Myers, J. G. (2020). Credible practice of modeling and simulation in healthcare: Ten rules from a multidisciplinary perspective. *Journal of Translational Medicine*, *18*(1). https://doi.org/10.1186/s12967-020-02540-4

Errasti-Ibarrondo, B., Jordán, J. A., Díez-Del-Corral, M. P., & Arantzamendi, M. (2018). Conducting phenomenological research: Rationalizing the methods and rigour of the phenomenology of practice. *Journal of Advanced Nursing*, *74*(7), 1723-1734. https://doi.org/10.1111/jan.13569

Falcone, A., & Garro, A. (2019). Distributed Co-simulation of complex engineered systems by combining the high level architecture and functional Mock-up

interface. *Simulation Modelling Practice and Theory*, *97*, 101967. https://doi.org/10.1016/j.simpat.2019.101967

Fan, S., Hua, Z., Storey, V. C., & Zhao, J. L. (2016). A process ontology-based approach to easing semantic ambiguity in business process modeling. *Data & Knowledge Engineering*, *102*, 57-77. https://doi.org/10.1016/j.datak.2016.01.001

Faqih, K. M., & Jaradat, M. R. (2015). Assessing the moderating effect of gender differences and individualism-collectivism at individual-level on the adoption of mobile commerce technology: TAM3 perspective. *Journal of Retailing and Consumer Services*, *22*, 37-52. https://doi.org/10.1016/j.jretconser.2014.09.006

Fayoumi, A., & Loucopoulos, P. (2016). Conceptual modeling for the design of intelligent and emergent information systems. *Expert Systems with Applications*, *59*, 174-194. https://doi.org/10.1016/j.eswa.2016.04.019

FitzPatrick, B. (2019). Validity in qualitative health education research. *Currents in Pharmacy Teaching and Learning*, *11*(2), 211-217. https://doi.org/10.1016/j.cptl.2018.11.014

Flintoft, I. D., Dawson, J. F., Dawson, L., Marvin, A. C., Alvarez, J., & Garcia, S. G. (2017). A modular test-suite for the validation and verification of electromagnetic solvers in electromagnetic compatibility applications. *IEEE Transactions on Electromagnetic Compatibility*, *59*(1), 111-118. https://doi.org/10.1109/temc.2016.2599004

Fujii, K., Nomura, K., Muramatsu, Y., Goto, T., Obara, S., Ota, H., & Tsukagoshi, S. (2020). Correlation analysis of organ doses determined by Monte Carlo simulation with dose metrics for patients undergoing chest-abdomen-pelvis CT

examinations. *Physica Medica*, *77*, 1-9. https://doi.org/10.1016/j.ejmp.2020.07.016

Fulton, E. A., Boschetti, F., Sporcic, M., Jones, T., Little, L. R., Dambacher, J. M., Gray, R., Scott, R., & Gorton, R. (2015). A multi-model approach to engaging stakeholders and modelers in complex environmental problems. *Environmental Science & Policy*, *48*, 44-56. https://doi.org/10.1016/j.envsci.2014.12.006

Fung, M. K. (2017). Fraudulent financial reporting and technological capability in the information technology sector: A resource-based perspective. *Journal of Business Ethics*, *156*(2), 577-589. https://doi.org/10.1007/s10551-017-3605-4

Furian, N., Neubacher, D., O'Sullivan, M., Walker, C., & Pizzera, C. (2018). GEDMod – Towards a generic toolkit for emergency department modeling. *Simulation Modelling Practice and Theory*, *87*, 239-273. https://doi.org/10.1016/j.simpat.2018.07.010

Furian, N., O'Sullivan, M., Walker, C., Vössner, S., & Neubacher, D. (2015). A conceptual modeling framework for discrete event simulation using hierarchical control structures. *Simulation Modelling Practice and Theory*, *56*, 82-96. https://doi.org/10.1016/j.simpat.2015.04.004

Fusch, P., & Ness, L. (2015). Are we there yet? Data saturation in qualitative research. *The Qualitative Report*, *20*(9), 1408-1416. http://www.nova.edu/

Gaetani, I., Hoes, P., & Hensen, J. L. (2020). A stepwise approach for assessing the appropriate occupant behaviour modelling in building performance simulation. *Journal of Building Performance Simulation*, *13*(3), 362-377. https://doi.org/10.1080/19401493.2020.1734660

GAO. (2013). *Information technology: OMB and agencies need to more effectively implement major initiatives to save billions of dollars* (GAO-13-796T). U.S. GAO. http://www.gao.gov/products/GAO-13-796T

GAO. (2016). *Information technology reform: Agencies need to increase their use of incremental development practices* (GAO-16-469). U.S. GAO. http://www.gao.gov/products/GAO-16-469

Gilmore, M. (2016a). *Director, operational test, and evaluation: FY 2016 annual report.* DoD DOT&E. https://www.dote.osd.mil/Publications/Annual-Reports/2016-Annual-Report/

Gilmore, M. (2016b). *Director, operational test, and evaluation: FY 2015 annual report*. DoD DOT&E. https://www.dote.osd.mil/Publications/Annual-Reports/2015-Annual-Report/

Gindre, J., Bel-Brunon, A., Rochette, M., Lucas, A., Kaladji, A., Haigron, P., & Combescure, A. (2017). Patient-specific finite-element simulation of the insertion of guidewire during an evar procedure: Guidewire position prediction validation on 28 cases. *IEEE Transactions on Biomedical Engineering*, *64*(5), 1057-1066. https://doi.org/10.1109/tbme.2016.2587362

Goda, K., Mori, N., & Yasuda, T. (2019). Rapid tsunami loss estimation using regional Inundation hazard metrics derived from stochastic tsunami simulation. *International Journal of Disaster Risk Reduction*, *40*. https://doi.org/10.1016/j.ijdrr.2019.101152

Goh, D. H., Pe-Than, E. P., & Lee, C. S. (2017). Perceptions of virtual reward systems in crowdsourcing games. *Computers in Human Behavior*, *70*, 365-374. https://doi.org/10.1016/j.chb.2017.01.006

Goh, Y. M., & Ali, M. J. (2016). A hybrid simulation approach for integrating safety behavior into construction planning: An earthmoving case study. *Accident Analysis & Prevention*, *93*, 310-318. https://doi.org/10.1016/j.aap.2015.09.015

Golroudbary, S. R., Zahraee, S. M., Awan, U., & Kraslawski, A. (2019). Sustainable operations management in logistics using simulations and modeling: A framework for decision making in delivery management. *Procedia Manufacturing*, *30*, 627-634. https://doi.org/10.1016/j.promfg.2019.02.088

Golzarpoor, H., González, V. A., O'Sullivan, M., Shahbazpour, M., Walker, C. G., & Poshdar, M. (2017). A non-queue-based paradigm in Discrete-Event-Simulation modeling for construction operations. *Simulation Modelling Practice and Theory*, *77*, 49-67. https://doi.org/10.1016/j.simpat.2017.05.004

Goodell, L. S., Stage, V. C., & Cooke, N. K. (2016). Practical qualitative research strategies: Training interviewers and coders. *Journal of Nutrition Education and Behavior*, *48*(8), 578-585.e1. https://doi.org/10.1016/j.jneb.2016.06.001

Gorecki, S., Bouanan, Y., Zacharewicz, G., Ribault, J., & Perry, N. (2018). Integrating HLA-based distributed simulation for management science and BPMN. *IFAC-PapersOnLine*, *51*(11), 655-660. https://doi.org/10.1016/j.ifacol.2018.08.393

Goulden, M., Greiffenhagen, C., Crowcroft, J., McAuley, D., Mortier, R., Radenkovic, M., & Sathiaseelan, A. (2016). Wild interdisciplinarity: ethnography and

computer science. *International Journal of Social Research Methodology*, *20*(2), 137-150. https://doi.org/10.1080/13645579.2016.1152022

Green, C. A., Duan, N., Gibbons, R. D., Hoagwood, K. E., Palinkas, L. A., & Wisdom, J. P. (2015). Approaches to mixed methods dissemination and implementation research: Methods, strengths, caveats, and opportunities. *Administration and Policy in Mental Health and Mental Health Services Research*, *42*, 508. https://doi.org/10.1007/s10488-014-0552-6

Gregory, J., Berthoud, L., Tryfonas, T., Rossignol, A., & Faure, L. (2020). The long and winding road: MBSE adoption for functional avionics of spacecraft. *Journal of Systems and Software*, *160*. https://doi.org/10.1016/j.jss.2019.110453

Grubic, T. (2018). Remote monitoring technology and servitization: Exploring the relationship. *Computers in Industry*, *100*, 148-158. https://doi.org/10.1016/j.compind.2018.05.002

Grzybowska, H., Kerferd, B., Gretton, C., & Waller, T. (2020). A simulation-optimisation genetic algorithm approach to product allocation in vending machine systems. *Expert Systems with Applications*, *145*, 113110. https://doi.org/10.1016/j.eswa.2019.113110

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods*, *18*(1), 59-82. https://doi.org/10.1177/1525822x05279903

Gunadi. (2015). Modeling impacts of maintenance, staff management and collaboration on e-government website availability: A qualitative system dynamics approach.

Procedia Computer Science, *72*, 145-153. https://doi.org/10.1016/j.procs.2015.12.115

Hamilton, A. B., & Finley, E. P. (2019). Qualitative methods in implementation research: An introduction. Psychiatry Research, *280*. https://doi.org/10.1016/j.psychres.2019.112516

Hansen, J. M., Saridakis, G., & Benson, V. (2018). Risk, trust, and the interaction of perceived ease of use and behavioral control in predicting consumers' use of social media for transactions. *Computers in Human Behavior*, *80*, 197-206. https://doi.org/10.1016/j.chb.2017.11.010

Hathaway, M., & Cross, D. (2016). The military learner: The acceptance of new training technology for C-130 aircrews. *International Journal of Aviation, Aeronautics, and Aerospace*, *3*(2). https://doi.org/10.15394/ijaaa.2016.1102

Hawkins, T., & Gravier, M. (2018). *The use of COTS in defense acquisition programs: A research synthesis and framework* (NPS Report No. SYM-AM-18-076). Calhoun: The NPS Institutional Archive. https://hdl.handle.net/10945/58758

Heath, J., Williamson, H., Williams, L., & Harcourt, D. (2018). "It's just more personal": Using multiple methods of qualitative data collection to facilitate participation in research focusing on sensitive subjects. *Applied Nursing Research*, *43*, 30-35. https://doi.org/10.1016/j.apnr.2018.06.015

Heikkinen, T., Johansson, J., & Elgh, F. (2017). Extended CAD-models — State of practice within three companies. *2017 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*. https://doi.org/10.1109/ieem.2017.8290060

Hein, J., Hippeli, J., & Eibert, T. F. (2018). Efficient EMC parameter analysis for the verification of complex automotive simulation models by the utilization of design of experiments. *Ieee Transactions on Electromagnetic Compatibility*, *60*(6), 1965-1973. https://doi.org/10.1109/temc.2017.2784879

Hennink, M. M., Kaiser, B. N., & Marconi, V. C. (2017). Code saturation versus meaning saturation: How many interviews are enough? *Qualitative Health Research*, *27*(4), 591-608. https://doi.org/10.1177/1049732316665344

Hershberger, P. E., & Kavanaugh, K. (2017). Comparing appropriateness and equivalence of email interviews to phone interviews in qualitative research on reproductive decisions. *Applied Nursing Research*, *37*, 50-54. https://doi.org/10.1016/j.apnr.2017.07.005

Hicks, J. L., Uchida, T. K., Seth, A., Rajagopal, A., & Delp, S. L. (2015). Is my model good enough? Best practices for verification and validation of musculoskeletal models and simulations of movement. *Journal of Biomechanical Engineering*, *137*(2), 1-24. https://doi.org/10.1115/1.4029304

Hidayatno, A., Destyanto, A. R., & Handoyo, B. A. (2019). A conceptualization of renewable energy-powered industrial cluster development in Indonesia. *Energy Procedia*, *156*, 7-12. https://doi.org/10.1016/j.egypro.2018.11.074

Hilal, M., Maqsood, T., & Abdekhodaee, A. (2019). A hybrid conceptual model for BIM in FM. *Construction Innovation*, *19*(4), 531-549. https://doi.org/10.1108/ci-05-2018-0043

Hoeber, L., & Shaw, S. (2017). Contemporary qualitative research methods in sport management. *Sport Management Review*, *20*(1), 4-7. https://doi.org/10.1016/j.smr.2016.11.005

Hoogendoorn, M., Ramos, I., Baldwin, M., Guix, N., & Mölken, M. P. (2019). Broadening the perspective of cost-effectiveness modeling in chronic obstructive pulmonary disease: A new patient-level simulation model suitable to evaluate stratified medicine. *Value in Health*, *22*(3), 313-321. https://doi.org/10.1016/j.jval.2018.10.008

Hornbæk, K., & Hertzum, M. (2017). Technology acceptance and user experience: A review of the experiential component in HCI. *ACM Transactions on Computer-Human Interaction (TOCHI)*, *24*(5), 1-30. https://doi.org/10.1145/3127358

Huang, L., Gao, C., Guo, F., & Sun, C. (2017). Lightning indirect effects on helicopter: Numerical simulation and experiment validation. *IEEE Transactions on Electromagnetic Compatibility*, *59*(4), 1171-1179. https://doi.org/10.1109/temc.2017.2651900

Hwang, Y., Al-Arabiat, M., & Shin, D. (2016). Understanding technology acceptance in a mandatory environment: A literature review. *Information Development*, *32*(4), 1266-1283. https://doi.org/10.1177/0266666915593621

Ifenthaler, D., & Schweinbenz, V. (2016). Students' acceptance of tablet PCs in the classroom. *Journal of Research on Technology in Education*, *48*(4), 306-321. https://doi.org/10.1080/15391523.2016.1215172

Ismail, U. M., & Islam, S. (2020). A unified framework for cloud security transparency and audit. *Journal of Information Security and Applications*, *54*, 102594. https://doi.org/10.1016/j.jisa.2020.102594

Issa Mattos, D., Bosch, J., & Olsson, H. H. (2019). Multi-armed bandits in the wild: Pitfalls and strategies in online experiments. *Information and Software Technology*, *113*, 68-81. https://doi.org/10.1016/j.infsof.2019.05.004

Izuagbe, R., & Popoola, S. O. (2017). Social influence and cognitive instrumental factors as facilitators of perceived usefulness of electronic resources among library personnel in private universities in South-west, Nigeria. *Library Review*, *66*(8/9), 679-694. https://doi.org/10.1108/lr-09-2016-0086

Jahangirian, M., Taylor, S. J., Young, T., & Robinson, S. (2017). Key performance indicators for successful simulation projects. *Journal of the Operational Research Society*, *68*(7), 747-765. https://doi.org/10.1057/jors.2016.1

James, J., Coutts, J., & Gururajan, R. (2015). It's all about the benefits: why extension professionals adopt Web 2.0 technologies. *Rural Extension & Innovation Systems Journal*, *11*(1), 72-82. https://www.apen.org.au/rural-extension-and-innovation-systems-journal

Jensen, J. A., Cobbs, J. B., & Turner, B. A. (2016). Evaluating sponsorship through the lens of the resource-based view: The potential for sustained competitive advantage. *Business Horizons*, *59*(2), 163-173. https://doi.org/10.1016/j.bushor.2015.11.001

Jnitova, V., Elsawah, S., & Ryan, M. (2017). Review of simulation models in military workforce planning and management context. *The Journal of Defense Modeling*

and Simulation: Applications, Methodology, Technology, *14*(4), 447-463. https://doi.org/10.1177/1548512917704525

Jolak, R., Ho-Quang, T., Chaudron, M. R., & Schiffelers, R. R. (2018). Model-based software engineering: A multiple-case study on challenges and development efforts. *Proceedings of the 21st ACM/IEEE International Conference on Model Driven Engineering Languages and Systems - MODELS '18*, 213-223. https://doi.org/10.1145/3239372.3239404

Jumadi, Carver, S., & Quincey, D. (2017). A conceptual design of spatio-temporal agent-based model for volcanic evacuation. *Systems*, *5*(4), 53. https://doi.org/10.3390/systems5040053

Justus, M. (2017). The role of pedagogical beliefs in emerging technology integration: An exploratory case study of faculty perspectives. *The Qualitative Report*, *22*(2), 499-526. https://nsuworks.nova.edu/tqr/

Kamp, K., Herbell, K., Magginis, W. H., Berry, D., & Given, B. (2019). Facebook recruitment and the protection of human subjects. *Western Journal of Nursing Research*, *41*(9), 1270-1281. https://doi.org/10.1177/0193945919828108

Kendall, R. P., Votta, L. G., Post, D. E., Moyer, E. T., & Morton, S. A. (2017). Verification and validation in CREATE multiphysics HPC software applications. *Computing in Science & Engineering*, *19*(6), 18-26. https://doi.org/10.1109/mcse.2017.3971169

Kim, T., Poplin, G., Bollapragada, V., Daniel, T., & Crandall, J. (2020). Monte Carlo method for estimating whole-body injury metrics from pedestrian impact

simulation results. *Accident Analysis & Prevention*, *147*. https://doi.org/10.1016/j.aap.2020.105761

Kirby, A., Anklam, C. E., & Dietz, J. E. (2016). Active shooter mitigation for gun-free zones. *2016 IEEE Symposium on Technologies for Homeland Security (HST)*. https://doi.org/10.1109/ths.2016.7568957

Kotir, J. H., Brown, G., Marshall, N., & Johnstone, R. (2017). Systemic feedback modeling for sustainable water resources management and agricultural development: An application of participatory modeling approach in the Volta River Basin. *Environmental Modelling & Software*, *88*, 106-118. https://doi.org/10.1016/j.envsoft.2016.11.015

Kovalchuk, S. V., Metsker, O. G., Funkner, A. A., Kisliakovskii, I. O., Nikitin, N. O., Kalyuzhnaya, A. V., Vaganov, D. A., & Bochenina, K. O. (2018). A conceptual approach to complex model management with generalized modelling patterns and evolutionary identification. *Complexity*, *2018*, 1-15. https://doi.org/10.1155/2018/5870987

Krapohl, D., Schubel, A., Frojdh, E., Thungstrom, G., & Frojdh, C. (2016). Validation of Geant4 pixel detector simulation framework by measurements with the Medipix family detectors. *Ieee Transactions on Nuclear Science*, *63*(3), 1874-1881. https://doi.org/10.1109/tns.2016.2555958

Laage, T., Loewy, J., Menon, S., Miller, E., Pulkstenis, E., Kan-Dobrosky, N., & Coffey, C. (2017). Ethical considerations in adaptive design clinical trials. *Therapeutic Innovation & Regulatory Science*, *51*(2), 190-199. https://doi.org/10.1177/2168479016667766

Landrum, B., & Garza, G. (2015). Mending fences: Defining the domains and approaches of quantitative and qualitative research. *Qualitative Psychology*, *2*, 199 –209. https://doi.org/10.1037/qup0000030

Lang, S., Reggelin, T., & Wunder, T. (2017). Mesoscopic simulation models for logistics planning tasks in the automotive industry. *Procedia Engineering*, *178*, 298-307. https://doi.org/10.1016/j.proeng.2017.01.118

Langer, K., Olson, S., Brockman, R., Braisted, W., Spradlin, T., & Fitzpatrick, M. E. (2015). High strain-rate material model validation for laser peening simulation. *The Journal of Engineering*, *2015*(13), 150-157. https://doi.org/10.1049/joe.2015.0118

Larsson, D., Spuhler, J. H., Petersson, S., Nordenfur, T., Colarieti-Tosti, M., Hoffman, J., Winter, R., & Larsson, M. (2017). Patient-specific left ventricular flow simulations from transthoracic echocardiography: Robustness evaluation and validation against ultrasound doppler and magnetic resonance imaging. *IEEE Transactions on Medical Imaging*, *36*(11), 2261-2275. https://doi.org/10.1109/tmi.2017.2718218

Lattal, K., & Yoshioka, M. (2017). Improving the human instrument. *Revista Mexicana de Análisis de la Conducta*, *43*(2), 177-191. https://doi.org/10.5514/rmac.v43.i2.62312

Levy, Y., & Green, B. D. (2009). An empirical study of computer self-efficacy and the Technology Acceptance Model in the military: A case of a U.S. Navy combat information system. *Journal of Organizational and End User Computing*, *21*(3), 1-23. https://doi.org/10.4018/joeuc.2009070101

Li, M., Porter, A. L., & Suominen, A. (2018). Insights into relationships between disruptive technology/innovation and emerging technology: A bibliometric perspective. *Technological Forecasting and Social Change*, *129*, 285-296. https://doi.org/10.1016/j.techfore.2017.09.032

Liang, X., Liu, X., Li, X., Chen, Y., Tian, H., & Yao, Y. (2018). Delineating multi-scenario urban growth boundaries with a CA-based FLUS model and morphological method. *Landscape and Urban Planning*, *177*, 47-63. https://doi.org/10.1016/j.landurbplan.2018.04.016

Liao, H., & Hitchcock, J. (2018). Reported credibility techniques in higher education evaluation studies that use qualitative methods: A research synthesis. *Evaluation and Program Planning*, *68*, 157-165. https://doi.org/10.1016/j.evalprogplan.2018.03.005

Liebel, G., Tichy, M., & Knauss, E. (2018). Use, potential, and showstoppers of models in automotive requirements engineering. *Software & Systems Modeling*. https://doi.org/10.1007/s10270-018-0683-4

Lin, J., Li, X., Li, S., & Wen, Y. (2020). What is the influence of landscape metric selection on the calibration of land-use/cover simulation models? *Environmental Modelling & Software*, *129*. https://doi.org/10.1016/j.envsoft.2020.104719

Liu, L., Ma, Y., Park, C., & Byun, J. (2019). Robust sequential bifurcation for simulation factor screening under data contamination. *Computers & Industrial Engineering*, *129*, 102-112. https://doi.org/10.1016/j.cie.2019.01.017

Longman, M., & Miles, S. B. (2019). Using discrete event simulation to build a housing recovery simulation model for the 2015 Nepal earthquake. *International Journal*

of Disaster Risk Reduction, *35*, 101075. https://doi.org/10.1016/j.ijdrr.2019.101075

Low, J. (2019). A pragmatic definition of the concept of theoretical saturation. *Sociological Focus*, *52*(2), 131-139. https://doi.org/10.1080/00380237.2018.1544514

Luminea, C. M., Donovan, J., & Tormey, D. (2015). Application of systems simulation for predicting and optimising energy requirements for HDF production. *Journal of Industrial Engineering*, *2015*, 1-16. https://doi.org/10.1155/2015/650925

Mahjoubpour, B., Nasirzadeh, F., Golabchi, M., Khajehghiasi, M., & Mir, M. (2018). Modeling of workers' learning behavior in construction projects using agent-based approach. *Engineering, Construction, and Architectural Management*, *25*(4), 559-573. https://doi.org/10.1108/ecam-07-2016-0166

Makaci, M., Reaidy, P., Evrard-Samuel, K., Botta-Genoulaz, V., & Monteiro, T. (2017). Pooled warehouse management: An empirical study. *Computers & Industrial Engineering*, *112*, 526-536. https://doi.org/10.1016/j.cie.2017.03.005

Malsch, B., & Salterio, S. (2016). "Doing good field research": Assessing the quality of audit field research. *AUDITING: A Journal of Practice & Theory*, *35*(1), 1-22. https://doi.org/10.2308/ajpt-51170

Malterud, K., Siersma, V. D., & Guassora, A. D. (2016). Sample size in qualitative interview studies: Guided by information power. *Qualitative Health Research*, *26*(13), 1753-1760. https://doi.org/10.1177/1049732315617444

Mandal, P. C. (2018). Qualitative research: Criteria of evaluation. *International Journal of Academic Research and Development*, *3*(2), 591-596. https://doi.org/10.22271/academic

Mao, C., Sun, C., & Chen, C. (2017). Evaluate learner's acceptance of augmented reality-based military decision-making process training system. *Proceedings of the 5th International Conference on Information and Education Technology - ICIET '17*. https://doi.org/10.1145/3029387.3029418

Maramwidze-Merrison, E. (2016). Innovative methodologies in qualitative research: Social media window for accessing organisational elites for interviews. *Electronic Journal of Business Research Methods*, *14*, 157-167. http://www.ejbrm.com

Marangunić, N., & Granić, A. (2015). Technology Acceptance Model: A literature review from 1986 to 2013. *Universal Access in the Information Society*, *14*(1), 81–95. doi.10.1007/s10209-014-0348-1

Marshall, B., Cardon, P., Poddar, A., & Fontenot, R. (2013). Does sample size matter in qualitative research?: A review of qualitative interviews in is research. Journal of *Computer Information Systems*, *54*(1), 11-22. https://doi.org/10.1080/08874417.2013.11645667

Marshall, S., Burghaus, R., Cosson, V., Cheung, S., Chenel, M., DellaPasqua, O., Frey, N., Hamrén, B., Harnisch, L., Ivanow, F., Kerbusch, T., Lippert, J., Milligan, P., Rohou, S., Staab, A., Steimer, J., Tornøe, C., & Visser, S. (2016). Good practices in model-informed drug discovery and development: Practice, application, and documentation. *CPT: Pharmacometrics & Systems Pharmacology*, *5*(3), 93-122. https://doi.org/10.1002/psp4.12049

Martell, C. C., & Stevens, K. M. (2019). Culturally sustaining social studies teachers: Understanding models of practice. *Teaching and Teacher Education*, *86*. https://doi.org/10.1016/j.tate.2019.102897

Martin, F., Ritzhaupt, A., Kumar, S., & Budhrani, K. (2019). Award-winning faculty online teaching practices: Course design, assessment and evaluation, and facilitation. *The Internet and Higher Education*, *42*, 34-43. https://doi.org/10.1016/j.iheduc.2019.04.001

Maunganidze, F. (2019). Methodological challenges in interviewing classic professionals within a declining socio-economic environment. *Journal of Contemporary Management*, *16*(2), 472-490. https://doi.org/10.35683/jcm19016.0023

McCrudden, M. T., Marchand, G., & Schutz, P. (2019). Mixed methods in educational psychology inquiry. *Contemporary Educational Psychology*, *57*, 1-8. https://doi.org/10.1016/j.cedpsych.2019.01.008

McGrath, C., Palmgren, P. J., & Liljedahl, M. (2018). Twelve tips for conducting qualitative research interviews. *Medical Teacher*, *41*(9), 1002-1006. https://doi.org/10.1080/0142159x.2018.1497149

McHaney, R., Reychav, I., Zhu, L., Lindstrom, M. M., & Arbel, Y. (2018). Iterative conceptual modeling: A case study in cardiac patient survival simulation. *Operations Research for Health Care*, *19*, 57-65. https://doi.org/10.1016/j.orhc.2018.03.002

McHenry, W. K. (2016). Online MBA programs and the threat of disruptive innovation. *The International Journal of Management Education*, *14*(3), 336-348. https://doi.org/10.1016/j.ijme.2016.07.002

Mensah, P., Merkuryev, Y., Klavins, E., & Manak, S. (2017). Supply chain risks analysis of a logging company: Conceptual model. *Procedia Computer Science*, *104*, 313-320. https://doi.org/10.1016/j.procs.2017.01.140

Meyer, Y., Pehlke-Milde, J., Muntwyler, F. S., & Fleming, V. (2019). Integrative power in Swiss home-like childbirths: A qualitative multiple case study. *Midwifery*, *78*, 97-103. https://doi.org/10.1016/j.midw.2019.08.005

Micciche, G., Lorenzelli, L., Frascati, F., Di Gironimo, G., & Mozzillo, R. (2017). Remote handling refurbishment process for the European IFMIF target assembly: Concept design, simulation, and validation in virtual environment. *IEEE Transactions on Plasma Science*, *45*(7), 1824-1830. https://doi.org/10.1109/tps.2017.2713383

Miranda, C., Altermatt, F., Villagrán, I., & Goñi, J. (2020). Developing an innovative medical training simulation device for peripheral venous access: A user-centered design approach. *Healthcare*, *8*(4), 420. https://doi.org/10.3390/healthcare8040420

Mittal, V., & Davidson, A. (2020). Combining wargaming with modeling and simulation to project future military technology requirements. *IEEE Transactions on Engineering Management*, 1-13. https://doi.org/10.1109/tem.2020.3017459

Monem, R. (2015). Metacognition and Self-Scaffolding in MMORPGs: Case Study of an Adolescent Male Gamer. *The Qualitative Report*, *20*(4), 454-465. http://nsuworks.nova.edu/tqr/vol20/iss4/7

Monks, T., Van der Zee, D., Lahr, M. M., Allen, M., Pearn, K., James, M. A., Buskens, E., & Luijckx, G. (2017). A framework to accelerate simulation studies of

hyperacute stroke systems. *Operations Research for Health Care*, *15*, 57-67. https://doi.org/10.1016/j.orhc.2017.09.002

Montargot, N., & Ben Lahouel, B. (2018). The acceptance of technological change in the hospitality industry from the perspective of front-line employees. *Journal of Organizational Change Management*, *31*(3), 637-655. https://doi.org/10.1108/jocm-10-2016-0192

Moorley, C., & Cathala, X. (2018). How to appraise qualitative research. *Evidence Based Nursing*, *22*(1), 10-13. https://doi.org/10.1136/ebnurs-2018-103044

Moreau, K. A., & Eady, K. (2019). The benefits and challenges of involving adolescents in medical education: A qualitative study. *Academic Pediatrics*, *19*(1), 97-102. https://doi.org/10.1016/j.acap.2018.05.007

Morgan, J. S., Howick, S., & Belton, V. (2017). A toolkit of designs for mixing discrete event simulation and system dynamics. *European Journal of Operational Research*, *257*(3), 907-918. https://doi.org/10.1016/j.ejor.2016.08.016

Moss, S. M., Uluğ, Ö. M., & Acar, Y. G. (2019). Doing research in conflict contexts: Practical and ethical challenges for researchers when conducting fieldwork. *Peace and Conflict: Journal of Peace Psychology*, *25*(1), 86-99. https://doi.org/10.1037/pac0000334

Naderifar, M., Goli, H., & Ghaljaie, F. (2017). Snowball sampling: A purposeful method of sampling in qualitative research. *Strides in Development of Medical Education*, *14*(3). https://doi.org/10.5812/sdme.67670

Nagy, D., Schuessler, J., & Dubinsky, A. (2016). Defining and identifying disruptive innovations. *Industrial Marketing Management*, *57*, 119-126. https://doi.org/10.1016/j.indmarman.2015.11.017

Nalchigar, S., & Yu, E. (2018). Business-driven data analytics: A conceptual modeling framework. *Data & Knowledge Engineering*, *117*, 359-372. https://doi.org/10.1016/j.datak.2018.04.006

Nascimento, L. D., Souza, T. V., Oliveira, I. C., Moraes, J. R., Aguiar, R. C., & Silva, L. F. (2018). Theoretical saturation in qualitative research: an experience report in interview with schoolchildren. *Revista Brasileira de Enfermagem*, *71*(1), 228-233. https://doi.org/10.1590/0034-7167-2016-0616

Neuman, D. (2014). Qualitative research in educational communications and technology: A brief introduction to principles and procedures. *Journal of Computing in Higher Education, 26*(1), 69-86. https://doi.org/10.1007/s12528-014-9078-x

Neuwirth, C. (2017). System dynamics simulations for data-intensive applications. *Environmental Modelling & Software*, *96*, 140-145. https://doi.org/10.1016/j.envsoft.2017.06.017

Nguyen, T. H., Chileshe, N., Rameezdeen, R., & Wood, A. (2019). External stakeholder strategic actions in projects: A multi-case study. *International Journal of Project Management*, *37*(1), 176-191. https://doi.org/10.1016/j.ijproman.2018.12.001

Nguyen, T. T., Keupers, I., & Willems, P. (2018). Conceptual river water quality model with a flexible model structure. *Environmental Modelling & Software*, *104*, 102-117. https://doi.org/10.1016/j.envsoft.2018.03.014

Nicolaescu, P., Rosenstengel, M., Derntl, M., Klamma, R., & Jarke, M. (2018). Near real-time collaborative modeling for view-based web information systems engineering. *Information Systems*, *74*, 23-39. https://doi.org/10.1016/j.is.2017.07.008

Nicolaides, M., Theodorou, E., Emin, E. I., Theodoulou, I., Andersen, N., Lymperopoulos, N., Odejinmi, F., Kitapcioglu, D., Aksoy, M. E., Papalois, A., & Sideris, M. (2020). Team performance training for medical students: Low vs high fidelity simulation. *Annals of Medicine and Surgery*, *55*, 308-315. https://doi.org/10.1016/j.amsu.2020.05.042

Nikolic, N. (2020). Conceptual modelling in simulation of military logistics processes – Field maintenance modelling. *Journal of Defence & Security Technologies*, *3*(1), 100-110. https://doi.org/10.46713/jdst.003.06

Norris, L. A., Didymus, F. F., & Kaiseler, M. (2020). Understanding social networks and social support resources with sports coaches. *Psychology of Sport and Exercise*, *48*. https://doi.org/10.1016/j.psychsport.2020.101665

Oppl, S. (2016). Towards scaffolding collaborative articulation and alignment of mental models. *Procedia Computer Science*, 99, 125-145. https://doi.org/10.1016/j.procs.2016.09.106

Otieno, E. O., Wausi, A. N., & Kahonge, A. M. (2020). A theoretical model for information security policy compliance culture. *International Journal of Applied Information Systems (IJAIS)*, 12(33), 6-14. https://doi.org/10.5120/ijais2020451879

Padilha, J. M., Machado, P. P., Ribeiro, A. L., & Ramos, J. L. (2018). Clinical virtual simulation in nursing education. *Clinical Simulation in Nursing*, *15*, 13-18. https://doi.org/10.1016/j.ecns.2017.09.005

Parjanen, S., & Hyypiä, M. (2019). Innotin game supporting collective creativity in innovation activities. *Journal of Business Research*, *96*, 26-34. https://doi.org/10.1016/j.jbusres.2018.10.056

Park, S., Kotzev, M., Brüns, D., Kam, D., & Schuster, C. (2017). Lessons from applying IEEE standard 1597 for validation of computational electromagnetics computer modeling and simulations. *IEEE Electromagnetic Compatibility Magazine*, *6*(2), 55 - 67. https://doi.org/10.1109/MEMC.0.7989999

Patel, E. A., Aydin, A., Cearns, M., Dasgupta, P., & Ahmed, K. (2020). A systematic review of simulation-based training in neurosurgery, Part 1: Cranial neurosurgery. *World Neurosurgery*, *133*, e850-e873. https://doi.org/10.1016/j.wneu.2019.08.262

Patten, E., Ozuem, W., Howell, K., & Lancaster, G. (2020). Minding the competition: The drivers for multichannel service quality in fashion retailing. *Journal of Retailing and Consumer Services*, *53*, 101974. https://doi.org/10.1016/j.jretconser.2019.101974

Pedram, A., Yusoff, N. B., Udoncy, O. E., Mahat, A. B., Pedram, P., & Babalola, A. (2017). Integrated forward and reverse supply chain: A tire case study. *Waste Management*, *60*, 460-470. https://doi.org/10.1016/j.wasman.2016.06.029

Peitso, L., & Brutzman, D. (2020). Defeating lag in network-distributed physics simulations. *Graphical Models*, *111*, 101075. https://doi.org/10.1016/j.gmod.2020.101075

Peters, A. (2016). Modified conceptual model for compensated root water uptake – A simulation study. *Journal of Hydrology*, *534*, 1-10. https://doi.org/10.1016/j.jhydrol.2015.12.047

Phillippi, J., & Lauderdale, J. (2017). A guide to field notes for qualitative research: Context and conversation. *Qualitative Health Research*, *28*(3), 381-388. https://doi.org/10.1177/1049732317697102

Phillips, D. M., Mazzuchi, T. A., & Sarkani, S. (2018). An architecture, system engineering, and acquisition approach for space system software resiliency. *Information and Software Technology*, *94*, 150-164. https://doi.org/10.1016/j.infsof.2017.10.006

Pinho, T., Coelho, J., Moreira, A., & Boaventura-Cunha, J. (2016). Modeling a biomass supply chain through discrete-event simulation. *IFAC-PapersOnLine*, *49*(2), 84-89. https://doi.org/10.1016/j.ifacol.2016.03.015

Plano Clark, V. L. (2019). Meaningful integration within mixed methods studies: Identifying why, what, when, and how. *Contemporary Educational Psychology*, *57*, 106-111. https://doi.org/10.1016/j.cedpsych.2019.01.007

Pongjetanapong, K., O'Sullivan, M., Walker, C., & Furian, N. (2018). Implementing complex task allocation in a cytology lab via HCCM using Flexsim HC. *Simulation Modelling Practice and Theory*, *86*, 139-154. https://doi.org/10.1016/j.simpat.2018.05.007

Popli, M., Ladkani, R. M., & Gaur, A. S. (2017). Business group affiliation and post-acquisition performance: An extended resource-based view. *Journal of Business Research*, *81*, 21-30. https://doi.org/10.1016/j.jbusres.2017.08.003

Popoola, O. R., & Sinanović, S. (2018). Design and analysis of collision reduction algorithms for Led-based indoor positioning with simulation and experimental validation. *IEEE Access*, *6*, 10754-10770. https://doi.org/10.1109/access.2018.2801626

Powell, J. H., & Mustafee, N. (2017). Widening requirements capture with soft methods: an investigation of hybrid M&S studies in health care. *Journal of the Operational Research Society*, *68*(10), 1211-1222. https://doi.org/10.1057/s41274-016-0147-6

Power, W., Jeffrey, A., & Robinson, K. (2018). Applying model-based system engineering to modelling and simulation requirements for weapon analysis. *2018 IEEE Aerospace Conference*. https://doi.org/10.1109/aero.2018.8396501

Pratimaratri, U., Ilona, D., & Zaitul. (2019). Digital medical data protection compliance among medical staffs. *Journal of Physics: Conference Series*, *1339*, 012100. https://doi.org/10.1088/1742-6596/1339/1/012100

Priyadarshini, C., Kumar, Y., & Jha, R. R. (2017). Employer Attractiveness Through Social Media: A Phenomenological Study. *The Qualitative Report*, *22*(4), 969-983. http://nsuworks.nova.edu/tqr/vol22/iss4/3

Proctor, M. D., & Campbell-Wynn, L. (2014). Effectiveness, usability, and acceptability of haptic-enabled virtual reality and mannequin modality simulators for surgical cricothyroidotomy. *Military Medicine*, *179*(3), 260-264. https://doi.org/10.7205/milmed-d-13-00365

Proudlove, N., Bisogno, S., Onggo, B., Calabrese, A., & Levialdi Ghiron, N. (2017). Towards fully-facilitated discrete event simulation modeling: Addressing the

model coding stage. *European Journal of Operational Research*, *263*(2), 583-595. https://doi.org/10.1016/j.ejor.2017.06.002

Qutoshi, S. B. (2018). Phenomenology: A philosophy and method of inquiry. *Journal of Education and Educational Development*, *5*(1), 215-222. https://doi.org/10.22555/joeed.v5i1.2154

Rad, F., & Rowzan, S. M. (2018). Designing a hybrid system dynamic model for analyzing the impact of strategic alignment on project portfolio selection. *Simulation Modelling Practice and Theory*, *89*, 175-194. https://doi.org/10.1016/j.simpat.2018.10.001

Råheim, M., Magnussen, L. H., Sekse, R. J., Lunde, Å., Jacobsen, T., & Blystad, A. (2016). Researcher–researched relationship in qualitative research: Shifts in positions and researcher vulnerability. *International Journal of Qualitative Studies on Health and Well-being*, *11*(1). https://doi.org/10.3402/qhw.v11.30996

Rajanen, D., & Weng, M. (2017). Digitization for fun or reward? A study of acceptance of wearable devices for personal healthcare. *AcademicMindtrek '17 Proceedings of the 21st International Academic Mindtrek Conference*, 154-163. https://doi.org/10.1145/3131085.3131118

Ramadan, R., & Aita, J. (2018). A model of mobile payment usage among Arab consumers. *International Journal of Bank Marketing*. https://doi.org/10.1108/ijbm-05-2017-0080

Rapport, F., Clement, C., Doel, M. A., & Hutchings, H. A. (2015). Qualitative research and its methods in epilepsy: Contributing to an understanding of patients' lived

experiences of the disease. *Epilepsy & Behavior*, *45*, 94-100. https://doi.org/10.1016/j.yebeh.2015.01.040

Raskind, I. G., Shelton, R. C., Comeau, D. L., Cooper, H. L., Griffith, D. M., & Kegler, M. C. (2018). A review of qualitative data analysis practices in health education and health behavior research. *Health Education & Behavior*, *46*(1), 32-39. https://doi.org/10.1177/1090198118795019

Rasoulkhani, K., Mostafavi, A., Reyes, M. P., & Batouli, M. (2020). Resilience planning in hazards-humans-infrastructure nexus: A multi-agent simulation for exploratory assessment of coastal water supply infrastructure adaptation to sea-level rise. *Environmental Modelling & Software*, *125*. https://doi.org/10.1016/j.envsoft.2020.104636

Rauschnabel, P. A., & Ro, Y. K. (2016). Augmented reality smart glasses: an investigation of technology acceptance drivers. *International Journal of Technology Marketing*, *11*(2), 123. https://doi.org/10.1504/ijtmkt.2016.075690

Razmak, J., & Bélanger, C. (2018). Using the technology acceptance model to predict patient attitude toward personal health records in regional communities. *Information Technology & People*, *31*(2), 306-326. https://doi.org/10.1108/itp-07-2016-0160

Reinhardt, R., & Gurtner, S. (2018). The overlooked role of embeddedness in disruptive innovation theory. *Technological Forecasting and Social Change*, *132*, 268-283. https://doi.org/10.1016/j.techfore.2018.02.011

Reitz, E. A., & Seavey, K. (2018). Making joint and multinational simulation interoperability a reality. *Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC) 2018*. http://www.iitsecdocs.com/search

Rese, A., Baier, D., Geyer-Schulz, A., & Schreiber, S. (2017). How augmented reality apps are accepted by consumers: A comparative analysis using scales and opinions. *Technological Forecasting and Social Change*, *124*, 306-319. https://doi.org/10.1016/j.techfore.2016.10.010

Rieb, J. T., Chaplin-Kramer, R., Daily, G. C., Armsworth, P. R., Böhning-Gaese, K., Bonn, A., Cumming, G. S., Eigenbrod, F., Grimm, V., Jackson, B. M., Marques, A., Pattanayak, S. K., Pereira, H. M., Peterson, G. D., Ricketts, T. H., Robinson, B. E., Schröter, M., Schulte, L. A., Seppelt, R., … Bennett, E. M. (2017). When, where, and how nature matters for ecosystem services: Challenges for the next generation of ecosystem service models. *BioScience*, *67*(9), 820-833. https://doi.org/10.1093/biosci/bix075

Rodič, B. (2017). Industry 4.0 and the new simulation modeling paradigm. *Organizacija*, 50(3), 193-207. https://doi.org/10.1515/orga-2017-0017

Rogers, R. (2016). Using lenses to make sense of research: A review of Sharon M. Ravitch and Matthew Riggan's Reason & rigor: How conceptual frameworks guide research. *The Qualitative Report*, *21*(9), 1708-1712. https://nsuworks.nova.edu/tqr/

Rondan-Cataluña, F., Arenas-Gaitán, J., & Ramírez-Correa, P. (2015). A comparison of the different versions of popular technology acceptance models: A non-linear perspective. *Kybernetes*, *44*(5), 788-805. https://doi.org/10.1108/k-09-2014-0184

Rosenthal, M. (2016). Qualitative research methods: Why, when, and how to conduct interviews and focus groups in pharmacy research. *Currents in Pharmacy Teaching and Learning*, *8*(4), 509-516. https://doi.org/10.1016/j.cptl.2016.03.021

Sadagic, A., Brutzman, D., & Friedell, M. (2016). *CAD interoperability for navy reuse in additive manufacturing (AM), 3D printing, maintenance and training* (NPS Report No. NPS-FY16-N169-A). Calhoun: The NPS Institutional Archive. https://hdl.handle.net/10945/57741

Sadagic, A., & Yates, F. (2015). *Large scale adoption of training simulations: Are we there yet?* (Publication No. 15256) Calhoun: The NPS Institutional Archive. https://hdl.handle.net/10945/48451

Salem, F., Elhillali, Y., & Niar, S. (2017). User model-based method for IEEE 802.11p performance evaluation in vehicular safety applications. *2017 IEEE International Conference on Vehicular Electronics and Safety (ICVES)*. https://doi.org/10.1109/icves.2017.7991902

Salmona, M., & Kaczynski, D. (2016). Don't blame the software: Using qualitative data analysis software successfully in doctoral research. *Forum Qualitative Sozialforschung*, *17*(3). https://doi.org/10.17169/fqs-17.3.2505

Samonas, S., Dhillon, G., & Almusharraf, A. (2020). Stakeholder perceptions of information security policy: Analyzing personal constructs. *International Journal of Information Management*, *50*, 144-154. https://doi.org/10.1016/j.ijinfomgt.2019.04.011

Sanakulov, N., Kalliomaa, S., & Karjaluoto, H. (2018). Salesperson adoption and usage of mobile sales configuration tools. *Journal of Systems and Information Technology*. https://doi.org/10.1108/jsit-09-2017-0073

Sandstrom, J. K., & Reynolds, D. E. (2019). Leading a successful hotel: A look at the general manager's ability to utilize multiple leadership styles. *International Journal of Hospitality Management*. https://doi.org/10.1016/j.ijhm.2019.102399

Santos-Nunes, M., Narciso, I., Vieira-Santos, S., & Roberto, M. S. (2017). Parenting and emotional well-being of adoptive school-aged children: The mediating role of attachment. *Children and Youth Services Review*, *81*, 390-399. https://doi.org/10.1016/j.childyouth.2017.08.026

Sapat, A., Schwartz, L., Esnard, A., & Sewordor, E. (2017). Integrating qualitative data analysis software into doctoral public administration education. *Journal of Public Affairs Education*, *23*(4), 959-978. https://doi.org/10.1080/15236803.2017.12002299

Sayeed, L., & Onetti, A. (2018). The relationship between organizational resources and green IT/S adoption: A RBV approach. *Journal of International Technology and Information Management*, *27*(2), 43-72. https://scholarworks.lib.csusb.edu/jitim/vol27/iss2/3

Scheidegger, A., Pereira, T., Oliveira, M., Banerjee, A., & Montevechi, J. (2018). An introductory guide for hybrid simulation modelers on the primary simulation methods in industrial engineering identified through a systematic review of the literature. *Computers & Industrial Engineering*, *124*, 474-492. https://doi.org/10.1016/j.cie.2018.07.046

Seo, K., Hong, W., & Kim, T. G. (2017). Enhancing model composability and reusability for entity-level combat simulation: A conceptual modeling approach. *Simulation*, *93*(10), 825-840. https://doi.org/10.1177/0037549717699872

Shachak, A., Kuziemsky, C., & Petersen, C. (2019). Beyond TAM and UTAUT: Future directions for HIT implementation research. *Journal of Biomedical Informatics*, *100*. https://doi.org/10.1016/j.jbi.2019.103315

Shahin, M., Babar, M. A., & Chauhan, M. A. (2020). Architectural design space for modelling and simulation as a service: A review. *Journal of Systems and Software*, *170*, 110752. https://doi.org/10.1016/j.jss.2020.110752

Shao, F., Peng, R., Lai, H., & Wang, B. (2017). DRank: A semi-automated requirements prioritization method based on preferences and dependencies. *Journal of Systems and Software*, *126*, 141-156. https://doi.org/10.1016/j.jss.2016.09.043

Shin, B., & Lowry, P. B. (2020). A review and theoretical explanation of the 'cyberthreat-intelligence (CTI) capability' that needs to be fostered in information security practitioners and how this can be accomplished. *Computers & Security*, *92*, 101761. https://doi.org/10.1016/j.cose.2020.101761

Shin, D., & Jin Park, Y. (2017). Understanding the Internet of things ecosystem: Multi-level analysis of users, society, and ecology. *Digital Policy, Regulation and Governance*, *19*(1), 77-100. https://doi.org/10.1108/dprg-07-2016-0035

Shorey, S., Yang, Y. Y., & Dennis, C. (2018). A mobile health app–based postnatal educational program (home-but not alone): Descriptive qualitative study. *Journal of Medical Internet Research*, *20*(4), e119. https://doi.org/10.2196/jmir.9188

Sim, J., Saunders, B., Waterfield, J., & Kingstone, T. (2018). Can sample size in qualitative research be determined a priori? *International Journal of Social Research Methodology*, *21*(5), 619-634. https://doi.org/10.1080/13645579.2018.1454643

Simmonds, C., Brentnall, M., & Lenihan, J. (2020). Can robotic surgery VR-simulation metrics be used to devise a universal proficiency index that would allow comparisons for all users? *Journal of Minimally Invasive Gynecology*, *27*(7). https://doi.org/10.1016/j.jmig.2020.08.036

Singh, A., Klarner, P., & Hess, T. (2019). How do chief digital officers pursue digital transformation activities? The role of organization design parameters. *Long Range Planning*, 101890. https://doi.org/10.1016/j.lrp.2019.07.001

Smith, B. (2018). Generalizability in qualitative research: Misunderstandings, opportunities and recommendations for the sport and exercise sciences. *Qualitative Research in Sport, Exercise and Health*, *10*(1), 137-149. https://doi.org/10.1080/2159676x.2017.1393221

Smith, D., & Srinivas, S. (2019). A simulation-based evaluation of warehouse check-in strategies for improving inbound logistics operations. *Simulation Modelling Practice and Theory*, *94*, 303-320. https://doi.org/10.1016/j.simpat.2019.03.004

Sorko, S., & Komar, J. (2020). Qualitative acceptance model of augmented reality from the perspective of personalists. *Tehnički glasnik*, *14*(3), 352-359. https://doi.org/10.31803/tg-20200719183209

Spreer, P., & Rauschnabel, P. A. (2016). Selling with technology: understanding the resistance to mobile sales assistant use in retailing. *Journal of Personal Selling &*

Sales Management, *36*(3), 240-263. https://doi.org/10.1080/08853134.2016.1208100

Squires, A., & Dorsen, C. (2018). Qualitative research in nursing and health professions regulation. *Journal of Nursing Regulation*, *9*(3), 15-26. https://doi.org/10.1016/s2155-8256(18)30150-9

Stadnicka, D., & Litwin, P. (2017). Value stream and system dynamics analysis – An automotive case study. *Procedia CIRP*, *62*, 363-368. https://doi.org/10.1016/j.procir.2016.06.038

Stanton, N. A., Harvey, C., & Allison, C. K. (2019). Systems theoretic accident model and process (STAMP) applied to a Royal Navy hawk jet missile simulation exercise. *Safety Science*, *113*, 461-471. https://doi.org/10.1016/j.ssci.2018.12.020

Steinmetz-Wood, M., Pluye, P., & Ross, N. A. (2019). The planning and reporting of mixed methods studies on the built environment and health. *Preventive Medicine*, *126*. https://doi.org/10.1016/j.ypmed.2019.105752

Stütz, T., Emsenhuber, G., Huber, D., Domhardt, M., Tiefengrabner, M., Oostingh, G. J., Fötschl, U., Matis, N., & Ginzinger, S. (2017). Mobile phone–supported physiotherapy for frozen shoulder: Feasibility assessment based on a usability study. *JMIR Rehabilitation and Assistive Technologies*, *4*(2), e6. https://doi.org/10.2196/rehab.7085

Swann, C., Keegan, R., Crust, L., & Piggott, D. (2016). Psychological states underlying excellent performance in professional golfers: "Letting it happen" vs. "making it happen". *Psychology of Sport and Exercise*, *23*, 101-113. https://doi.org/10.1016/j.psychsport.2015.10.008

Takeda Berger, S. L., Tortorella, G. L., & Frazzon, E. M. (2018). Simulation-based analysis of inventory strategies in lean supply chains. *IFAC-Papers OnLine*, *51*(11), 1453-1458. https://doi.org/10.1016/j.ifacol.2018.08.310

Tako, A., & Robinson, S. (2015). Is simulation in health different? *Journal of the Operational Research Society*, *66*(4), 602–614. https://doi.org/10.1057/jors.2014.25

Taylor, S. J. (2019). Distributed simulation: State-of-the-art and potential for operational research. *European Journal of Operational Research*, *273*(1), 1-19. https://doi.org/10.1016/j.ejor.2018.04.032

Tegegne, W. A., Moyle, B. D., & Becken, S. (2018). A qualitative system dynamics approach to understanding destination image. *Journal of Destination Marketing & Management*, *8*, 14-22. https://doi.org/10.1016/j.jdmm.2016.09.001

Tello-Leal, E., Villarreal, P. D., Chiotti, O., Rios-Alvarado, A. B., & Lopez-Arevalo, I. (2016). A technological solution to provide integrated and process-oriented care services in healthcare organizations. *IEEE Transactions on Industrial Informatics*, 12(4), 1508-1518. https://doi.org/10.1109/tii.2016.2587765

Thackray, D., & Roberts, L. (2017). Exploring the clinical decision-making used by experienced cardiorespiratory physiotherapists: A mixed method qualitative design of simulation, video recording and think-aloud techniques. *Nurse Education Today*, *49*, 96-105. https://doi.org/10.1016/j.nedt.2016.11.003

Theofanidis, D., & Fountouki, A. (2018). Limitations and delimitations in the research process. *Perioperative Nursing*, *7*(3), 155-162. https://doi.org/10.5281/zenodo.2552022

Torkura, K., Sukmana, M. I., Cheng, F., & Meinel, C. (2020). Continuous auditing & threat detection in multi-cloud infrastructure. *Computers & Security*, 1-18. https://doi.org/10.1016/j.cose.2020.102124

Tung, V. W., & Law, R. (2017). The potential for tourism and hospitality experience research in human-robot interactions. *International Journal of Contemporary Hospitality Management*, *29*(10), 2498-2513. https://doi.org/10.1108/ijchm-09-2016-0520

Twining, P., Heller, R. S., Nussbaum, M., & Tsai, C. (2017). Some guidance on conducting and reporting qualitative studies. *Computers & Education*, *106*. https://doi.org/10.1016/j.compedu.2016.12.002

Vaismoradi, M., Jones, J., Turunen, H., & Snelgrove, S. (2016). Theme development in qualitative content analysis and thematic analysis. *Journal of Nursing Education and Practice*, *6*(5). https://doi.org/10.5430/jnep.v6n5p100

Valentine, K. D., Kopcha, T. J., & Vagle, M. D. (2018). Phenomenological methodologies in the field of educational communications and technology. *TechTrends*, *62*(5), 462-472. https://doi.org/10.1007/s11528-018-0317-2

Vanbrabant, L., Martin, N., Ramaekers, K., & Braekers, K. (2019). Quality of input data in emergency department simulations: Framework and assessment techniques. *Simulation Modelling Practice and Theory*, *91*, 83-101. https://doi.org/10.1016/j.simpat.2018.12.002

Van der Linden, D., Hadar, I., & Zamansky, A. (2019). What practitioners really want: Requirements for visual notations in conceptual modeling. *Software & Systems Modeling*, *18*(3), 1813–1831. https://doi.org/10.1007/s10270-018-0667-4

Van De Weerd, I., Mangula, I. S., & Brinkkemper, S. (2016). Adoption of software as a service in Indonesia: Examining the influence of organizational factors. *Information & Management*, *53*(7), 915-928. https://doi.org/10.1016/j.im.2016.05.008

Varpio, L., Ajjawi, R., Monrouxe, L. V., O'Brien, B. C., & Rees, C. E. (2017). Shedding the cobra effect: problematising thematic emergence, triangulation, saturation and member checking. *Medical Education*, *51*(1), 40-50. https://doi.org/10.1111/medu.13124

Vázquez-Poletti, J., Moreno-Vozmediano, R., Han, R., Wang, W., & Llorente, I. (2017). SaaS enabled admission control for MCMC simulation in cloud computing infrastructures. *Computer Physics Communications*, *211*, 88-97. https://doi.org/10.1016/j.cpc.2016.07.004

Vecchiato, R. (2017). Disruptive innovation, managerial cognition, and technology competition outcomes. *Technological Forecasting and Social Change*, *116*, 116-128. https://doi.org/10.1016/j.techfore.2016.10.068

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the Technology Acceptance Model: Four longitudinal field studies. *Management Science*, *46*(2), 186-204.

Venselaar, M., & Wamelink, H. (2017). The nature of qualitative construction partnering research: literature review. *Engineering, Construction and Architectural Management, 24*(6), 1092-1118. https://doi.org/10.1108/ecam-04-2016-0098

Verhoog, R., Ghorbani, A., & Dijkema, G. P. (2016). Modeling socio-ecological systems with Maia: A biogas infrastructure simulation. *Environmental Modelling & Software*, *81*, 72-85. https://doi.org/10.1016/j.envsoft.2016.03.011

Verkuyl, M., Romaniuk, D., & Mastrilli, P. (2018). Virtual gaming simulation of a mental health assessment: A usability study. Nurse Education in Practice, *31*, 83-87. https://doi.org/10.1016/j.nepr.2018.05.007

Verma, S., Bhattacharyya, S. S., & Kumar, S. (2018). An extension of the technology acceptance model in the big data analytics system implementation environment. *Information Processing & Management*, *54*(5), 791-806. https://doi.org/10.1016/j.ipm.2018.01.004

Vile, J. L., Allkins, E., Frankish, J., Garland, S., Mizen, P., & Williams, J. E. (2017). Modeling patient flow in an emergency department to better understand demand management strategies. *Journal of Simulation*, *11*(2), 115-127. https://doi.org/10.1057/s41273-016-0004-2

Visser, S. A., Norton, J. D., Marshall, S., & O'Kelly, M. (2017). Common best practice in modeling and simulation across quantitative disciplines: A comparison of independently emerging proposals. *Statistics in Biopharmaceutical Research*, *10*(2), 72-75. https://doi.org/10.1080/19466315.2017.1385520

Walsh, R. (2015). Wise ways of seeing: Wisdom and perspectives. *Integral Review*, *11*(2), 156-175. http://integral-review.org/

Walther, A., Morner, M., & Calabrò, A. (2017). The role of behaviorally integrated nominating committees in non-executive director selection processes. *European Management Journal*, *35*(3), 351-361. https://doi.org/10.1016/j.emj.2016.10.004

Wang, K., Liu, Y., Li, J., Wang, B., Bishop, R., White, C., Das, A., Levine, A. D., Ho, L., Levine, B. L., & Fesnak, A. D. (2019). A multiscale simulation framework for the manufacturing facility and supply chain of autologous cell therapies. *Cytotherapy*, *21*(10), 1081-1093. https://doi.org/10.1016/j.jcyt.2019.07.002

Wang, L., Huang, M., & Liu, M. (2018). How founders' social capital affects the success of open-source projects: A resource-based view of project teams. *Electronic Commerce Research and Applications*, *30*, 51-61. https://doi.org/10.1016/j.elerap.2018.05.003

Wang, Y., Anne, A., & Ropp, T. (2016). Applying the Technology Acceptance Model to understand aviation students' perceptions toward augmented reality maintenance training instruction. *International Journal of Aviation, Aeronautics, and Aerospace*, *3*(4). https://doi.org/10.15394/ijaaa.2016.1144

Webb, A., & Welsh, A. J. (2019). Phenomenology as a methodology for scholarship of teaching and learning research. *Teaching & Learning Inquiry*, *7*(1), 168-181. https://doi.org/10.20343/teachlearninqu.7.1.11

Williams, R. A. (2018). Lessons learned on development and application of agent-based models of complex dynamical systems. *Simulation Modelling Practice and Theory*, *83*, 201-212. https://doi.org/10.1016/j.simpat.2017.11.001

Williams, V., Boylan, A., & Nunan, D. (2019). Critical appraisal of qualitative research: necessity, partialities and the issue of bias. *BMJ Evidence-Based Medicine*. https://doi.org/10.1136/bmjebm-2018-111132

Woods, M., Paulus, T., Atkins, D. P., & Macklin, R. (2016). Advancing qualitative research using qualitative data analysis software (QDAS)? Reviewing potential

versus practice in published studies using ATLAS.ti and NVivo, 1994–2013. *Social Science Computer Review*, *34*(5), 597-617. https://doi.org/10.1177/0894439315596311

Xiong, B., Li, B., Fan, R., Zhou, Q., & Li, W. (2017). Modeling and simulation for effectiveness evaluation of dynamic discrete military supply chain networks. *Complexity*, *2017*, 1-9. https://doi.org/10.1155/2017/6052037

Xu, Y., Tang, Y., Ren, L., Dai, Q., Xu, C., Wang, Z., Shi, J., Li, J., Liang, S., & Yan, S. (2016). Numerical simulation and experimental validation of a cooling process in a 150-kJ SMES magnet. *IEEE Transactions on Applied Superconductivity*, *26*(6), 1-7. https://doi.org/10.1109/tasc.2016.2535262

Yang, H., Lee, H., & Zo, H. (2017). User acceptance of smart home services: An extension of the theory of planned behavior. *Industrial Management & Data Systems*, *117*(1), 68-89. https://doi.org/10.1108/imds-01-2016-0017

Yang, Y., Schofield, N., & Emadi, A. (2016). Double-rotor switched reluctance machine design, simulations, and validations. *IET Electrical Systems in Transportation*, *6*(2), 117-125. https://doi.org/10.1049/iet-est.2015.0028

Yaseen, S. G., & El Qirem, I. A. (2018). Intention to use e-banking services in the Jordanian commercial banks. *International Journal of Bank Marketing*, *36*(3), 557-571. https://doi.org/10.1108/ijbm-05-2017-0082

Yates, J., & Leggett, T. (2016). Qualitative research: An introduction. *Radiologic Technology*, *88*(2), 225-231. http://www.radiologictechnology.org/

Yilmaz Turali, E., & Simsek, S. (2017). Conceptual and 3D simulation modeling of the Sorgun hydrothermal reservoir (Yozgat, Turkey). *Geothermics*, *66*, 85-100. https://doi.org/10.1016/j.geothermics.2016.11.012

Yu, D., & Fang, C. (2017). The dynamics of public safety in cities: A case study of Shanghai from 2010 to 2025. *Habitat International*, *69*, 104-113. https://doi.org/10.1016/j.habitatint.2017.09.007

Yu, W., Chavez, R., Jacobs, M. A., & Feng, M. (2018). Data-driven supply chain capabilities and performance: A resource-based view. *Transportation Research Part E: Logistics and Transportation Review*, *114*, 371-385. https://doi.org/10.1016/j.tre.2017.04.002

Yuniarto, D., Helmiawan, M. A., & Firmansyah, E. (2018). Technology acceptance in augmented reality. *Journal Online Informatika (JOIN)*, *3*(1), 10-13. https://doi.org/10.15575/join.v3i1.158

Zappia, L., Phipson, B., & Oshlack, A. (2017). Splatter: Simulation of single-cell RNA sequencing data. *Genome Biology*, *18*. https://doi.org/10.1186/s13059-017-1305-0

Zhou, Y., & Herath, H. (2017). Evaluation of alternative conceptual models for groundwater modeling. *Geoscience Frontiers*, *8*(3), 437-443. https://doi.org/10.1016/j.gsf.2016.02.002

Zondag, M. M., Mueller, E. F., & Ferrin, B. G. (2017). The application of value nets in food supply chains: A multiple case study. Scandinavian Journal of Management, *33*(4), 199-212. https://doi.org/10.1016/j.scaman.2017.10.002

Appendix: Interview Protocol

Case No.			
Participant No.			
Interview Location	In-Person Face-to-Face	Face-to-Face Online	Phone

Pre-Interview Checks	• Verify consent form is signed. • Check recording device. • Interview setting is quiet and private. • Start stopwatch.
Introduction	My name is Cody Taylor and I am conducting this research as a component of a doctorate degree through Walden University. Also, I am a civil servant working for the USMC as a 2210 IT Project Manager. This research is not connected to my duties as a civil servant, which means I am conducting the research on my own time without the use of government resources. With this multiple-case study I hope to gather strategies some IT project managers are using to implement modeling and simulation technology in military organizations.
Ethical Obligations	This interview should be 30 to 60 minutes long depending on our dialogue. As stated in the consent form, your participation is strictly voluntary and can be stopped at any time, and for any reason. You may also choose to not answer any of the interview questions. Your identification, and the identification of your organization will be kept anonymous. Do you feel comfortable proceeding with the interview?
	I would like to record this interview so the questions and answers can be transcribed and analyzed at a later time. The recording and transcript will be encrypted and stored in a locked container for a period of five years. Only I will have access to the recording and transcript. Do I have permission to record this interview?
	Thank you for your participation. Your input will add to the body of knowledge and help practitioners implement M&S technology. Please refrain from sharing the real names of individuals and organizations, in order to protect the privacy of others. If you inadvertently use real names, I will remove the information from the transcripts. Do you have any questions before I start the recording?

BEGIN RECORDING	
Question 1	What strategies have you used to implement M&S technology?
Which of these strategies was the most effective? Which of these strategies was the least effective?	

Question 2	What challenges did you encounter, and how did you overcome them?
Question 3	How do you know when an M&S implementation is successful?
Question 4	Please briefly describe what you consider to be the most critical phases of M&S implementation.
What strategies, if any, were used to create conceptual models? What strategies, if any, were used for verification and validation?	
Question 5	What process do you use to determine the most appropriate M&S methodology?
What are the most commonly used M&S methodologies?	
Question 6	What strategies, if any, are used when selecting M&S development tools?
Are some M&S tools easier to use than others? Have you faced restrictions on using desired M&S tools?	
Question 7	Do you have anything else to add that I have not asked about M&S implementation?
Review Process	Ask for validation of your field notes. Ask for clarifications where needed. Confirm your interpretation of gestures, emotions, silences, or even irony.

Supporting Documents	Encourage participants to share any publicly releasable artifacts they feel are relevant to the research topic.
Recruit	Can you provide me with contact information of any potential participants you believe I should interview?
Closeout	Thank you so much for your participation. Your contributions are valuable additions to the research project. I will email you a summary of my interpretations of the interview so you have the opportunity to make corrections, additions, and provide any feedback you feel is necessary.