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Empirical Testing of Model Relativism Theory: Does Modeling Affect How Acquisition Stakeholders Think About the System Under Development?

February 8, 2021

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Abstract

The Department of Defense is adopting model-based systems engineering, in which models replace the extensive amounts of documentation generated in developing a new system. In this research, we examine how this shift from a textual description of requirements to a model-based description affects the requirements engineering process. Specifically, we conduct experiments to determine if models affect how stakeholders understand, reason, and make decisions concerning the acquisition of weapon systems. Following an experimental design, we split participants into two groups: group one was given a model-based specification, and group two was given a text-based specification of the same system. The results provide weak evidence for a difference in performance between the two groups—with model-based group performing better. Our research into model representation is part of a larger effort based on a theory of model relativity, which postulates that models affect how we think about the system of interest.

Keywords: model-based systems engineering, requirements engineering, language.

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Table of Contents

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List of Figures

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List of Tables

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Executive Summary

The Department of Defense is adopting model-based systems engineering, in which models will replace the extensive amounts of documentation generated in developing a new system. In this research, we examine how this shift from a textual description of requirements to a model-based description affects the requirements engineering process. Specifically, we ask whether engineers are able to extract the same understanding of the system requirements from the models as they can from the traditional textual requirements specifications.

To answer the research question, a research model linking the audience, modeling language, and system engineering process was developed. We create an experiment in which two test groups—a model-based group and a text-based group—interact with a specification for a military product. We gathered 40 responses. Eleven subjects completed the entire questionnaire, and 29 subjects' responses were incomplete. Four hypotheses were tested comparing the understandability, efficiency, and accuracy of the model-based versus text-based groups. The experimental results suggest a weak acceptance that a model-based group could be more effective than a text-based group.

The experiments conducted as part of this research project are among the first set of evidence about cognition with respect to models in systems engineering. Consequently, the results are of value to the larger systems engineering community and industry, which is also adopting a model-centric approach. Lastly, the research may be of interest to cognitive scientists and linguists as yet more evidence of language relativity being demonstrated in a more limited domain of discourse.

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Introduction

The systems engineering community, especially the aerospace sector, is quickly adopting a model-based systems engineering (MBSE) paradigm to replace the traditional document-driven approach. These models are largely conceptual models of system requirements, system structure, and other non-physics based models. This paper proposes a theory that we call model relativism theory claiming modeling languages shape how stakeholders reason about the system being modeled. The theory is motivated by Sapir–Whorf's theory, which claims that human language affects how people think. Models are created using a modeling language, and it is through the models that stakeholders communicate about a system. Growing evidence supports a weak version of Sapir–Whorf's theory, and it is plausible that systems engineering is a cognitive process and would also be affected by language, in this case modeling language.

Research Background

A long history of research has sought to better understand the connection between human cognition and language. One theory called *linguistic relativity* observes the diversity of human languages and claims that a person's language affects how they perceive the world and even affects how they think about phenomena (Gumperz & Levinson, 1996). The theory is now associated with Sapir and Whorf, who were early proponents of the idea (Whorf, 1956). The strong idea that language determines thought has mostly been dismissed by the research community, while the weaker version of how language may limit thought and influence thinking has gained wide acceptance substantiated with empirical data and results (Wolff & Holmes, 2011). Evidence now supports that language affects how people think about spatial arrangements, time events, and also how we think about physical objects (Boroditsky, 2003, 2011).

Many of the concepts surrounding linguistics apply equally to modeling languages, since in both cases a person uses the language to make and communicate statements about a phenomenon of interest. While researchers in modeling languages for the most part have not investigated language relativity theory, many engineering research streams do suggest the idea of modeling languages influencing how we think about systems. The Soft Systems Methodology uses the term *Weltanschuuang* to describe a worldview influencing how engineers define the problem and develop a system solution (Checkland, 1989). Bucciarelli (2002) and Ferguson (1994) both make a strong case that engineers think nonverbally, as evidenced by the use of drawings ranging from sketches to more formal blueprints; these authors then discuss how drawings shape our thinking about systems. Dori (2002) developed the Object-Process Methodology for modeling systems based on an assumption that humans need to simultaneously process images and words to convert data into understanding and knowledge about the system. His emphasis is on a modeling approach that acknowledges and accommodates human cognitive limits. Giachetti (2015) conducted a concordance analysis of the Department of Defense Architecture Framework's (DoDAF) underlying language with respect to systems engineering manuals and found many instances of poor support by DoDAF for some systems engineering activities and suggested that it might cause problems in completing the activity. So while the concept has been out there, nobody has conducted research to examine the link between modeling and engineering thought.

In summary, language relativity has been tested extensively, and evidence strongly suggests that language does influence how people think. In the domain of modeling languages, very few research efforts have investigated the relationship between modeling and human cognition.

Cognition and Visual Formats

Comprehension of information depends on factors such as experience, relevant knowledge, and expectations. A mental model is then constructed based on the information presented and the inferences drawn from other factors, such as implicit information conveyed through how it is presented. Replacing text with a visual representation of the same information must be able to convey the same information as textual presentation; however, visual representations will carry with them implicit information (e.g., spatial properties). Information displayed in visual formats can aid decision-making and performance by conveying a more complete representation when constructing a mental model (Johnson, 1980). Whether visual formats aid cognition depends on whether the graphics help the user search the data structure, recognize relevant information, and draw inferences (Larkin, 1987). If information is difficult to extract from the graphics, it becomes more burdensome to an individual's working memory capacity and can then be a hindrance to cognition. As stated by North (2012), engineers must decode the information presented in the models in order to achieve simple insights like finding and summarizing information, as well as complex insights such as finding patterns, making comparisons, and identifying outliers and anomalies. Kim et al. (2000) studied how subjects integrate information from multiple diagrams and found better integration of contextual and perceptual information and, therefore, better comprehension of the system when visual cues were in the diagrams to facilitate integration of the multiple views, which is relevant to modeling languages that use multiple diagrams. It appears that for simple tasks, visual and textual formats lead to equivalent performance; it is only for complex tasks that visual formats lead to superior performance.

The business process modeling literature has examined the understandability of business process models, which are just one type of requirements model (Reijers & Mendling, 2011). This stream of research has mainly presented the subjects with business process models followed by questions about the understanding of the model, and—as such—they have mostly tested perceptual processes. Gemino and Wand (2004) presented a framework to identify relevant factors for the empirical evaluation of conceptual modeling techniques and showed how to also include measures of effectiveness to address the analytical processes.

Moreover, the type of visual presentation of the information needs to be suitable for the task, which the researchers call *cognitive fit* (Vessey, 1991). Cognitive fit is when the cognitive processes to perform a task match the external representation of the problem. Various studies have confirmed cognitive fit leads to impoved performance by comparing tables versus graphs (Vessey, 1991) and object-oriented methods versus process-oriented methods (Agarwal, 1996).

Related to our comparison of model types is the work comparing process versus object-oriented tools, which found partial support for the cognitive fit theory (Agarwal & Sinha, 1999). Other similar research has investigated the interpretation of different diagram types (Brosey & Shneiderman, 1978; Yadav et al., 1988). However, the majority of these studies used novice subjects, often undergraduates.

A related stream of research examines what makes a good conceptual model and has led to many researchers specifying quality metrics for conceptual models. While some of the proposed quality metrics are grounded in semiotic theory (Lindland et al., 1994) or process modeling (Giachetti, 2017), many are better described as a collection of a well-argued list of attributes that one would want in a modeling language (Friedenthal et al., 2015; Paige et al., 2000).

Anda et al. (2001) conducted experiments comparing the understandability of use case models when generated via guidelines or via templates. They found that use cases derived from templates were easier for people to understand.

McDonough et al. (2000) posed a hypothesis based on observed differences between English and Korean with regard to spatial relationships. They then tested Korean and English speakers to see if there were differences.

Language has been shown to influence how people perceive the world, what they remember, and how they think about concepts. For example, Boroditzky (2003) observed that the Chinese language better reveals the underlying base-10 structure of the number system compared to English and suggested that this is one reason why Chinese children understand the underlying numbering system earlier than English speakers.

The understanding of MBSE and how it affects comprehension and reasoning should be guided by theories with explanatory power of the cognitive processes. We propose a theory to allow us to investigate modeling and model understanding from a cognitive perspective not yet discussed in the MBSE literature, thereby allowing for the possibility of extending our knowledge in this area.

The theories of how language influences cognition has not been explored in the realm of modeling and requirements engineering and may prove to be a rich area for furthering our knowledge of human cognition and the requirements engineering process.

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Research Model

This section describes the research model in terms of the independent and dependent variables and the hypothesized relationships between them. Figure 1 shows the structure of the research model. Problem-solving involves perceiving external representations to extract information and converting the information into an internal representation upon which production processes are used (Newell & Simon, 1972). The external representation is the *how* the information is encoded and can be textual requirement documents or requirement models. The internal representation is how the information and knowledge is encoded in our brains. System engineers document the requirements in some external representation, and the engineers and other stakeholders use the requirement documents to complete tasks requiring information input. Tasks requiring information input involve a perception process to understand the information and an analysis process to reason, make inferences, and make decisions to complete the task (Larkin & Simon, 1987). The perception process connects the external and internal representations. People perform the analysis process or reasoning based on mental models constructed from the information presented as well as relevant prior knowledge and expectations (Johnson-Laird, 2010). A mental model is an iconic representation corresponding to actual objects and relationships in the world, which supports our explanations, deductions, and inductions. Perception of reality varies among individuals and is shaped in part by language among other factors. Our interest is in how modeling languages might shape our perception of the information presented, which will affect reasoning processes.

The primary factor for the external representation is expressiveness. We define the expressiveness of a language according to the breadth of ideas the language can represent and communicate about the system. The expressiveness of a modeling language is its ability to generate scripts that capture information about a modeled domain. Expressiveness is related to the number of constructs in a language. Consequently, natural language has many more available constructs (i.e., words to express a concept) than a graphical modeling language such as SysML.

In addition to factors related to the external representation of the information, personal factors concerning the knowledge and experience of the person influences the ability of a person to perceive a model and do the analysis to complete a task (Reijers & Mendling, 2011). Domain knowledge and process knowledge are likely two personal factors affecting the performance of tasks. We are not interested in these effects, and in all experiments the subjects are drawn from similar backgrounds and experience to eliminate both domain and process knowledge as factors.

Task performance depends on both perceptual processes and analysis processes. Perception indicates that the subject is able to understand the information. Aranda et al. (2007) proposed the correctness or accuracy of the understanding, the time required to answer questions about the information, and the perceived difficulty of understanding the information. The latter is a subjective measure of understanding. These three measures are dependent variables of task performance in the model: accuracy, task time, and perceived difficulty. To test for understanding, we follow Mayer (1989), who argued that the application of knowledge in a meaningful way is a better indication of understanding and learning than questions focused primarily on recall.

Other research has found task complexity to be important because they only observe differences in performance between external representations when the task complexity is high. For this reason, we define complex tasks requiring more than information retrieval so that if there is a difference in performance, then it is more likely to be evident.

The overall hypothesis is that the modeling language affects a person's perception and analysis and ultimately how they think about a system.

A modeling language is unlike natural language because it is intentionally developed for narrow, specific goals and it carries the perspective of its developers. Experienced users of the model adapt and become proficient in the modeling language, which we hypothesize influences how they perceive and analyze the model data.

From the hypothesis we identify four research questions:

- RQ1: Can engineers extract the system requirements from the models?
- RQ2: Does MBSE increase the accuracy and efficiency of system engineering activities?
- RQ3: Are some models and/or modeling languages better at supporting certain tasks than others?
- RQ4: Do users of one modeling language exhibit differences in understanding and modeling of a system compared to users of another modeling language?

The first three research questions do not directly address the model language relativity theory we propose. They address task performance differences between documenting requirements in text versus models. The last research question directly addresses the model relativity theory and focuses on how the subjects think about the system based on the modeling language they use.

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Experiment

We developed an experiment to test the research questions. All the subjects are practicing system engineers in the Department of Defense acquisition workforce and are partway through a graduate program that includes modeling. Figure 1 shows the research model with hypothesized relationships between modeling language, the system engineering process, and the audience.

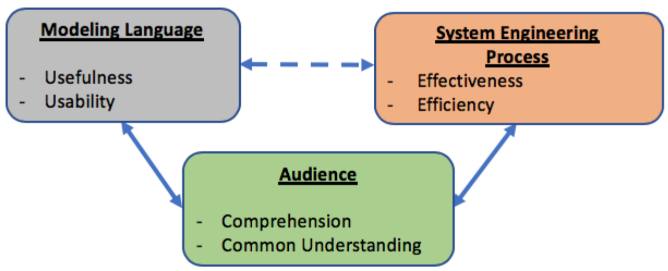

Figure 1. Research Model

The two-conditions experiment consisted of two different test groups: a model-based group and a text-based group. Subjects were randomly assigned to one of these groups, where each test group was given either the model-based or text-based specifications (see Figure 2), derived from the specification for a tactical sling (see Appendix for the model-based and text-based specifications). Noting that the functions of the tactical sling were generally user-centric, we selected specifications that illustrated these functions only in the operating requirements, interface and interoperability requirements, and support and ownership requirements.

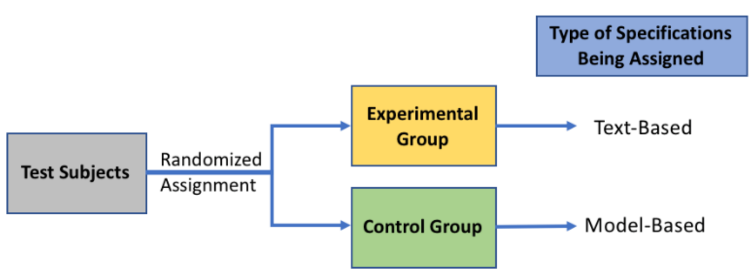

Figure 2. Experimental Design

Our dependent variable was the subjects' comprehension on the modeling language, and the independent variables were the modeling languages (models or text-based) used to represent the tactical sling specifications. To test the subjects' comprehension of the tactical sling specifications, the subjects had to complete an online questionnaire of open-ended and true-or-false questions based on the assigned specification type. The same set of questions were presented for both groups. There were two sections: requirements, and reference materials and demographics. Section 1 focused on the performance specifications of the tactical sling (see Table 1). For every question, the subjects had to answer the questions and provide the supporting information they used to derive the solution.

Table 1. Questionnaire Section 1

S/N	Requirements
1	List the physical components of the tactical sling.
2	What is the minimum and maximum width of the tactical sling belt?
3	List the tactical sling's functions that require interactions between the warfighter, weapon, and tactical sling.
4	List and describe the ways to detach the weapon.
5	Does the tactical sling allow both a left-handed and right-handed warfighter to operate the M16 and M4 series rifle?
6	Does the tactical sling support operations while wearing Mission Oriented Protective Posture (MOPP) IV gear?
7	Does the warfighter require a tool to attach the tactical sling onto the weapon?
8	Do you foresee the tactical sling causing any interference when used?
9	Do you foresee the tactical sling posing any risk while crossing water obstacles?
10	List and describe the different ways to attach the tactical sling to the weapon.

Section 2 acquired inputs about the reference materials presented and the demographics of the subjects (see Table 2).

Table 2. Questionnaire Section 2

S/N	Reference Materials and Demographics
1	How many times did you refer to the performance specification document?
2	Was it easy to find the information in the performance specification document to help you answer the questions?
3	Overall, how easy was it to understand the information in the performance specification document?
4	How many times did you refer to the FM 3–22 document?
5	Did you use any other sources besides the references provided in this survey?
6	List all education degrees you have (e.g., BS in aerospace engineering).
7	How many years of systems engineering experience do you have?
8	How many years of modeling or model-based system engineering (MBSE) experience do you have?
9	Rate your level of experience with either the M16 and/or M4 series rifle?
10	Have you ever used a tactical sling when shooting a rifle?
11	Any other comments?

Next, detailed examination of the accuracy of the subjects' answers to the questions and of the time taken to complete the questionnaire occurred.

The responses to the first 14 questions provide valuable insights on these sub-goals: effectiveness, efficiency, usefulness, and usability (see Figure 3). Using these metrics, the experiment hypotheses listed in Table 3 were tested.

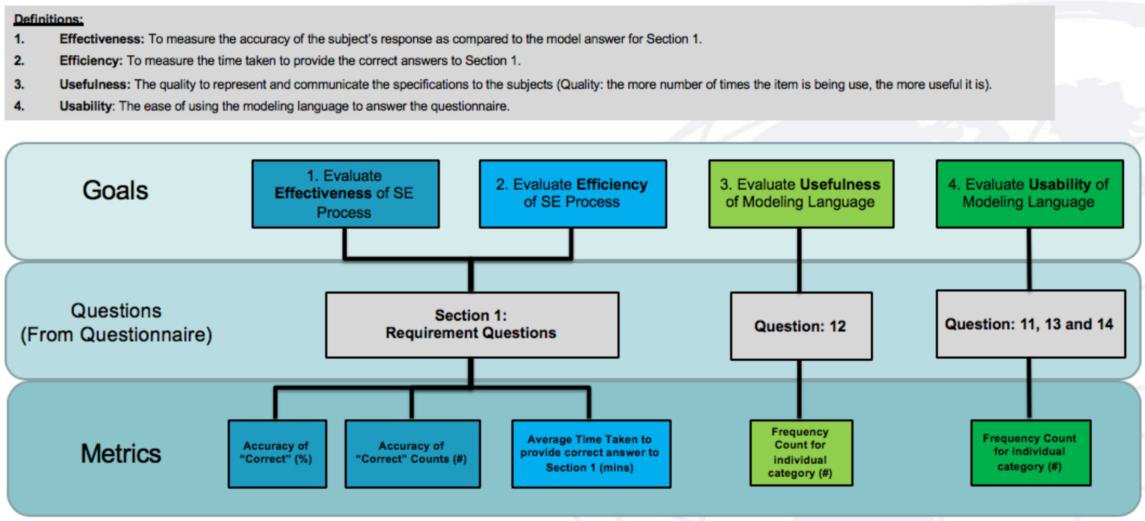

Figure 3. Goal Question Metric Approach

Table 3. Experimental Hypotheses

Hypothesis	H1: The average accuracy of answers for Section 1 is the same for the model-based and text-based groups.
	H2: The average time taken to provide "correct" answer for Section 1 is the same for the model-based and text-based groups.
	H3: The number of times which the subjects refer to the tactical sling specifications is the same for model-based and text-based groups.
	H4: The ease of finding information to answer the questions is the same for model-based and text-based groups.

Conduct of Experiment

The link to the questionnaire was sent to the subjects through their emails. In the first page, subjects' consent to participate in the questionnaire was requested. Thereafter, subjects were advised to read either the model-based or text-based tactical sling specifications for 15 minutes before answering the questionnaire. To prevent any possible interaction between subjects, the requirement questions in Section 1 were randomized for different subjects. Then, Section 2 acquired the demographics data of the subjects. This questionnaire was administered using the NPS LimeSurvey platform, whereby all survey data files were stored on a server behind NPS firewall.

Experimental Results

The experiment concluded with a total of 40 responses. As shown in Table 4, 11 subjects completed the questionnaire, and 29 subjects' responses were excluded due to incomplete responses. The subsequent section presents the results and elaborates on how the experiment goal was achieved.

Table 4. Summary of Questionnaire Responses

Total Responses	Completed	Incomplete Responses		
		Exited at Introduction Page	Exited at Consent Form	Exited Half Way
40	11	10	9	10

Here we show the results for each hypothesis.

H1: The average accuracy of answers for Section 1 is the same for the model-based and text-based groups.

Table 5 shows that the model-based group, on average, achieved higher accuracy of answers for Section 1 (mean values of 2.479 and 2.115) as compared to the text-based group (mean values of 2.175 and 2.046).

The first notable result was that the model-based group (in green) performed at least 25% better for Questions 1, 3, and 4 than the text-based group (in blue; see Figure 4). This suggests the strength of model-based to represent specification that covers more than one characteristic of the system.

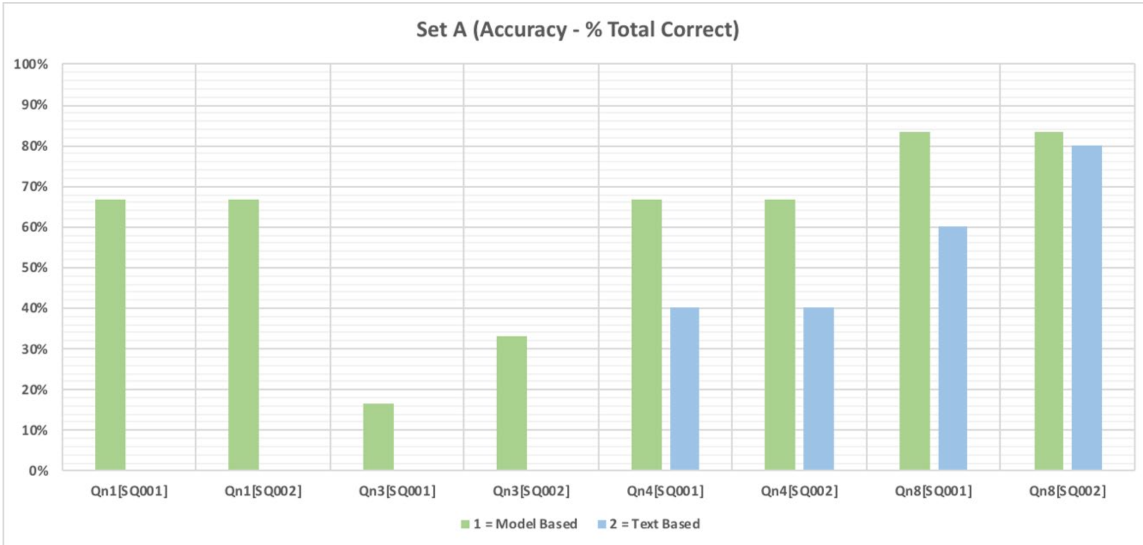

Figure 4. Total Correct Percentage for Set A Questions

For Set B questions, we found out that both groups performed relatively similarly for Questions 2, 5, 6, 7, and 10 (see Figure 5). This explains why the hypothesis was not rejected. This implies that specifications that are simple to comprehend can be represented by both models and text form.

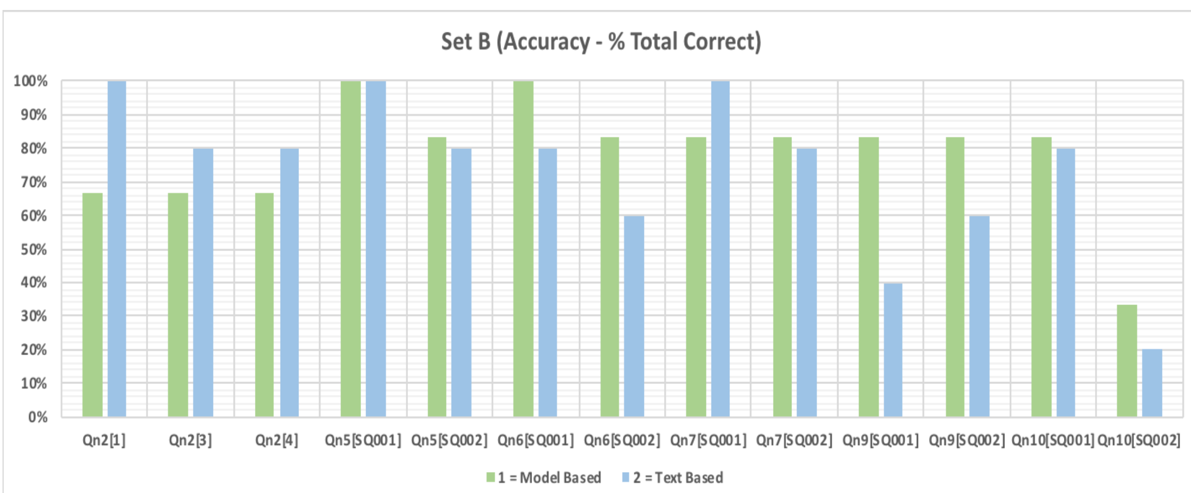

Figure 5. Total Correct Percentage for Set B Questions

Table 5. Descriptive Statistics for Hypothesis 1

Set	Language	Mean	SD	N
A	Model-Based	2.479	0.243	6
	Text-Based	2.175	0.328	5
B	Model-Based	2.115	0.422	6
	Text-Based	2.046	0.433	5

A two-sample t-test was conducted to reject the null hypothesis H1, which is an appropriate test to explore results from two independent variables (i.e., model-based and text-based) with a small sample size (i.e., less than 30). For Set A, we obtained a t-value that was larger than the critical t-value (2.105 > 1.771 [critical-t]). The null hypothesis H1 for Set A could be rejected with α=0.1. Conversely, for Set B, we did not reject the null hypothesis, as the t-value was smaller than the critical t-value (0.413 < 1.711 [critical-t]). Based on the results from Sets A and B, we conclude that the average accuracy of answers for Section 1 between model-based and text-based differs significantly.

H2: The average time taken to provide "Correct" answers for Section 1 is the same for the model-based and text-based groups.

Table 6 suggests that the model-based group took lesser total time to provide "Correct" answers for Section 1 (4.001 minutes) as compared to the text-based group (5.34 minutes). The text-based group had zero subjects who provided "correct" answers for Questions 1 and 3. Therefore, these results omitted the time taken for these two questions by the model-based group.

Table 6. Descriptive Statistics for H2

Set	Language	Mean (minutes)	SD	N
A	Model-Based	2.404	1.065	6
	Text-Based	4.849	5.488	5
B	Model-Based	1.597	4.880	6
	Text-Based	0.491	0.310	5
Total	Model-Based	4.001	-	6
	Text-Based	5.34	-	5

To reject the null hypothesis H2, a two-sample t-test was conducted. For Set A, we obtained a t-value that is larger than the negative critical-t value (−0.618 >

−6.314 [negative critical-t]). Conversely, for Set B, we acquired a t-value smaller than critical t-value ($1.64 < 2.57$ [critical t]). Therefore, we did not reject the null hypothesis H2 with α=0.1. The observed difference between the sample means Set A (2.404−1.597) and Set B (4.849−0.491) is not convincing enough that the average time taken to provide "Correct" answers for Section 1 differ significantly.

H3: The number of times that the subjects refer to the tactical sling specifications is the same for models-based and text-based groups.

Figure 6 indicates that there was no significant difference in the number of times that the subjects refer to the tactical sling specifications between the two groups. Both groups generally have a similar spread across all categories. With that, the usefulness of both types of performance specifications are the same.

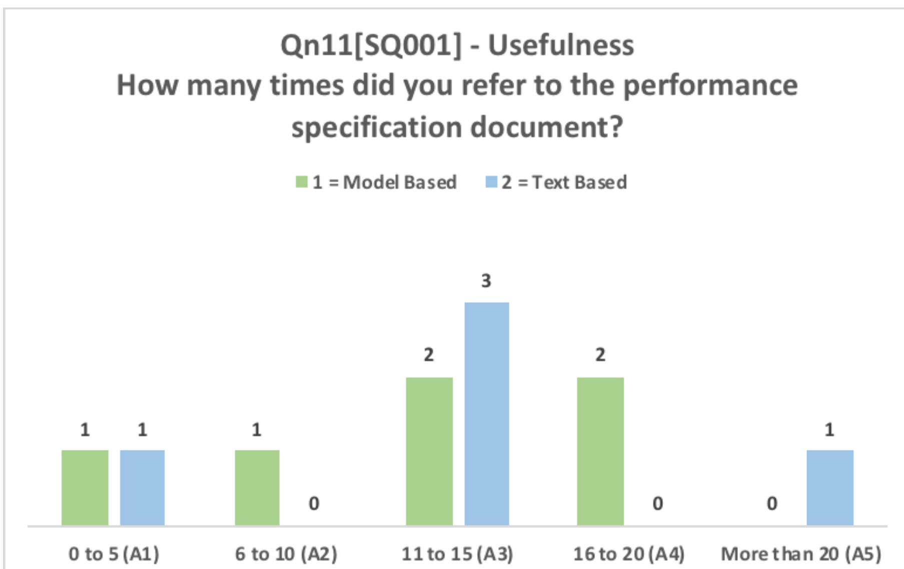

Figure 6. Usefulness of Performance Specifications

H4: The ease of finding information to answer the questions is the same for model-based and text-based groups.

Figure 7 suggests that the model-based group generally finds it easy to locate the relevant information from the model-based specifications as compared to the text-based group.

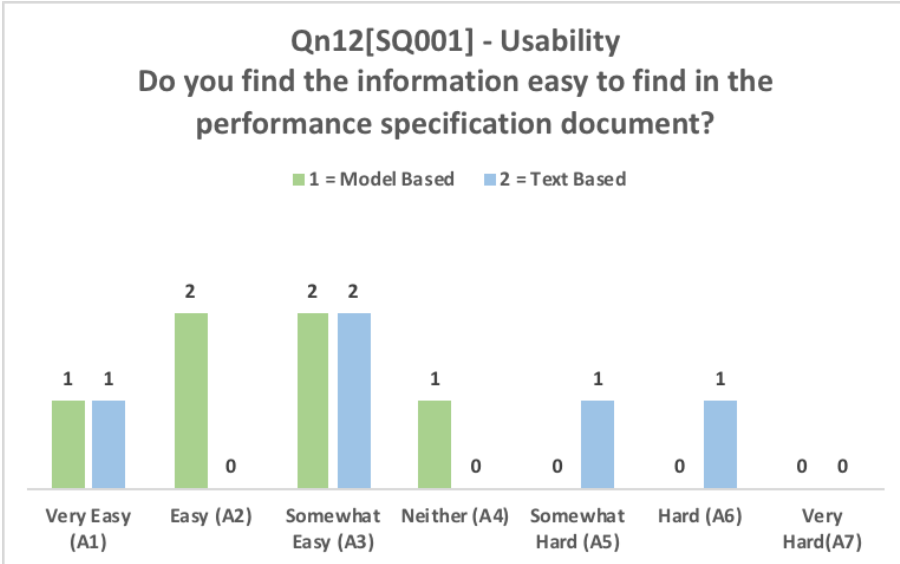

Figure 7. Summary on Usability of Performance Specification

Further details of the experimental study can be found in the thesis done by Chia (2019), who was supported by this research project.

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Summary

This paper described our research for investigation into how the adoption of MBSE affects the requirements engineering process in the Department of Defense acquisition process. The paper describes our theory called model relativity theory, which suggests that models affect human cognition. The theory is motivated by findings in natural language and cognition. We presented experiments to investigate whether engineers can extract requirements from models, whether MBSE increases the accuracy and efficiency of the requirements engineering process, and whether some models are better suited than others for requirements engineering tasks. The results provided weak evidence supporting the model relativism concept. Further and more extensive experimental studies are clearly needed to gather more conclusive evidence. The results of our research will inform the implementation of MBSE and also contribute to the literature a greater understanding of modeling and human cognition.

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Appendix. Model-Based and Text-Based Specifications Used in Experiments

1.0 SCOPE

1.1 Scope. This specification prescribes the performance requirements for the Tactical Sling. The Tactical Sling allows the Warfighter's weapon to remain in a ready position while conducting non-weapon firing-related tasks.

1.2 Requirement levels. This specification lists two values for certain performance parameters. The threshold (T) is the minimum acceptable level. The objective (O) is the desired level at which performance of the Tactical Sling results in an operationally significant increase in capabilities. When only one requirement is stated, it is the threshold requirement.

2.0 APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 of this specification. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3 of this specification, whether or not they are listed.

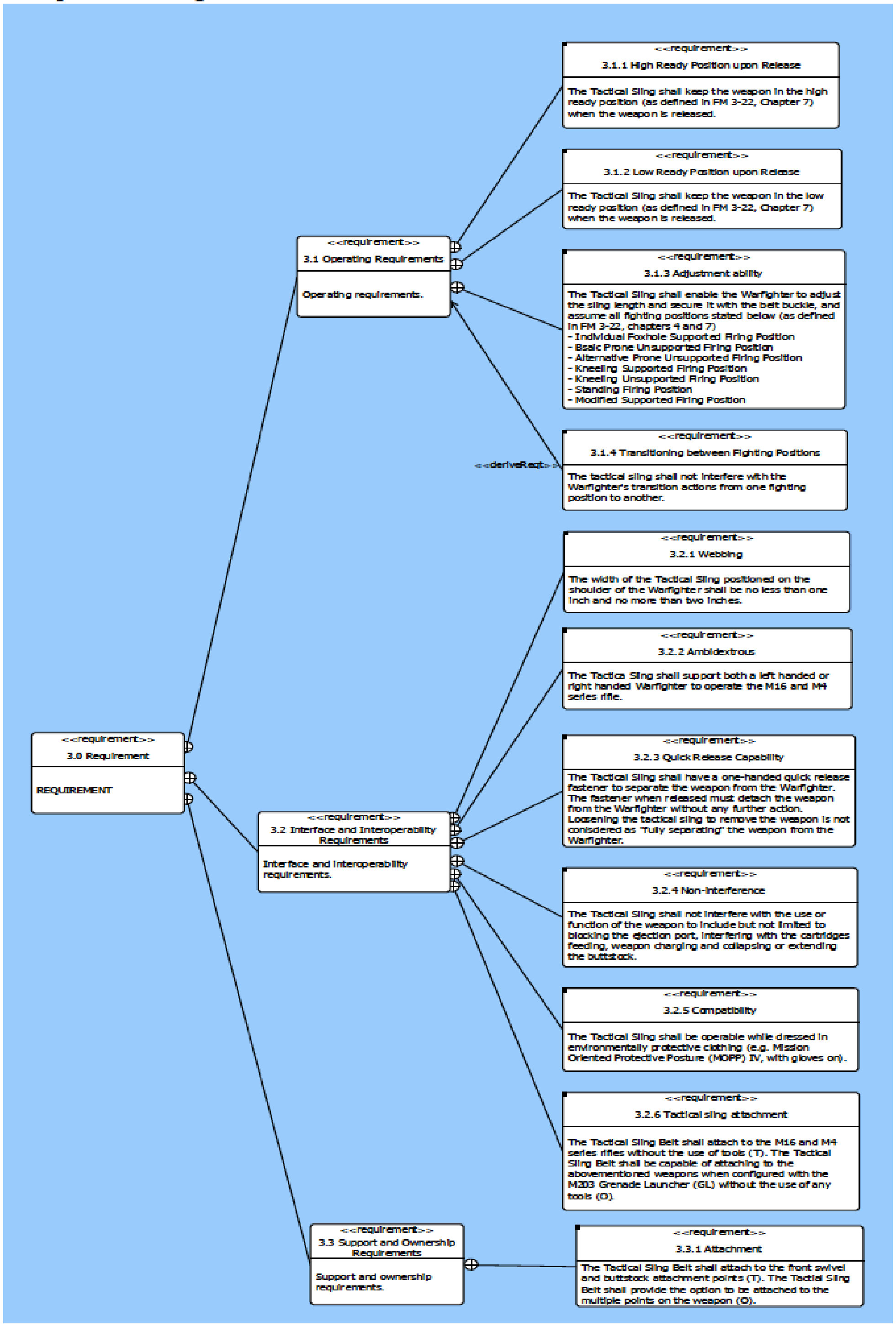
2.2 Government Document. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitations or contract.

ARMY FIELD MANUAL

FM 3-22 Rifle marksmanship M16A1, M16A2/3, M16A4, and M4 Carbine

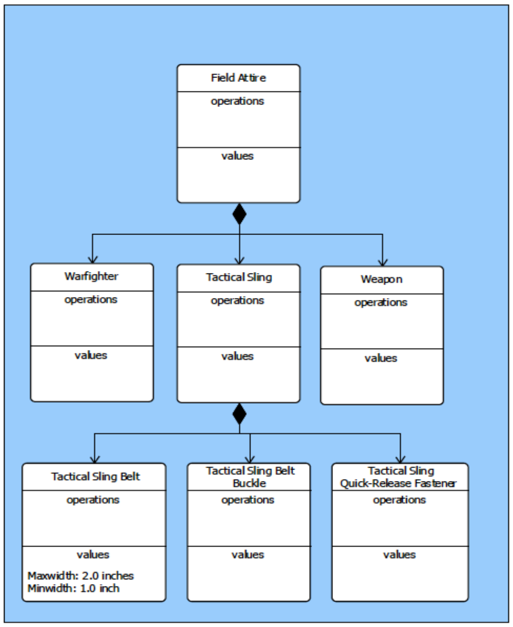
2

3. Requirements Diagrams

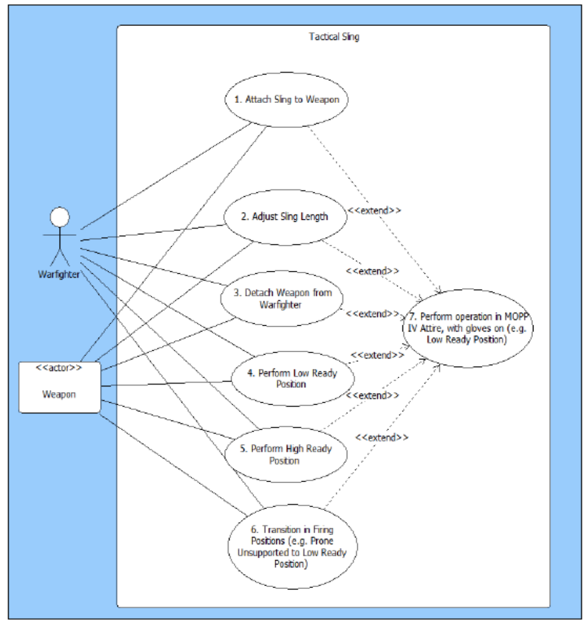


3

4. Block Definition Diagram (Field Attire)

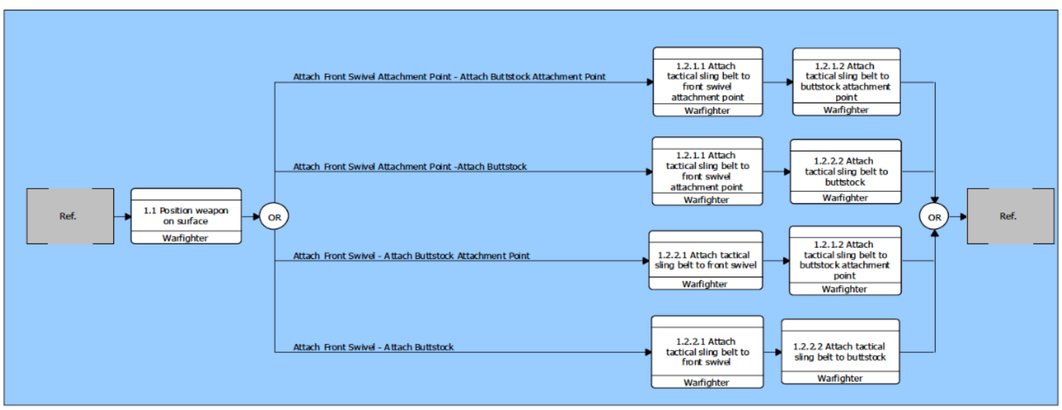


5. Use-Cases (Tactical Sling Operations)

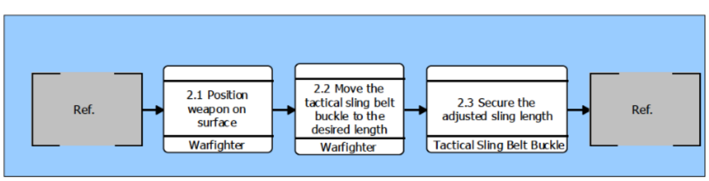


4

5A. Use-Case: Attach Sling to Weapon



5B. Use-Case: Adjust Sling Length



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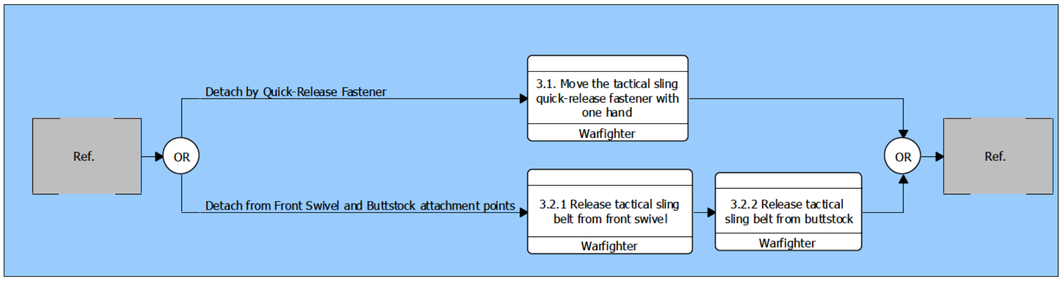
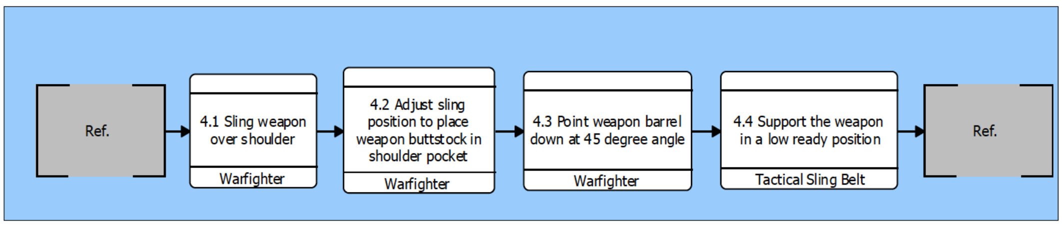
5C. Use-Case: Detach Weapon from Warfighter



5D. Use-Case: Perform Low Ready Position



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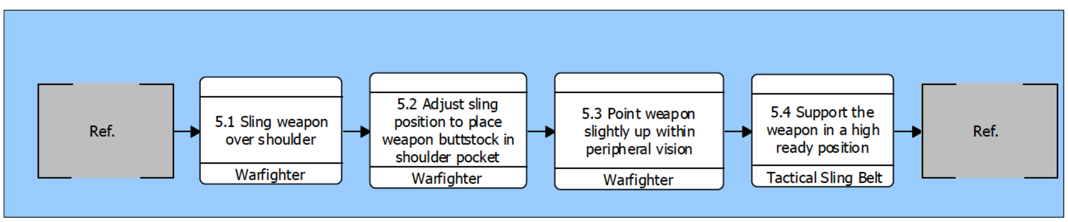
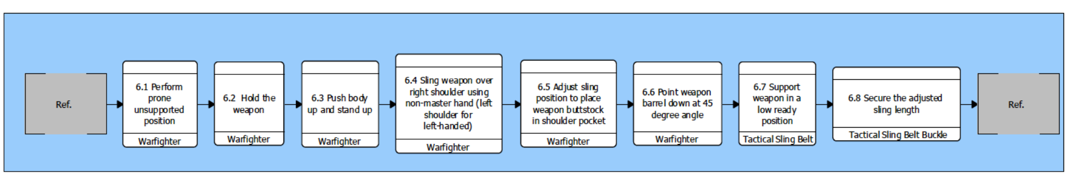
5E. Use-Case: Perform High Ready Position



5F. Use-Case: Transition in Fighting Position (e.g. Prone Unsupported to Low Ready Position)



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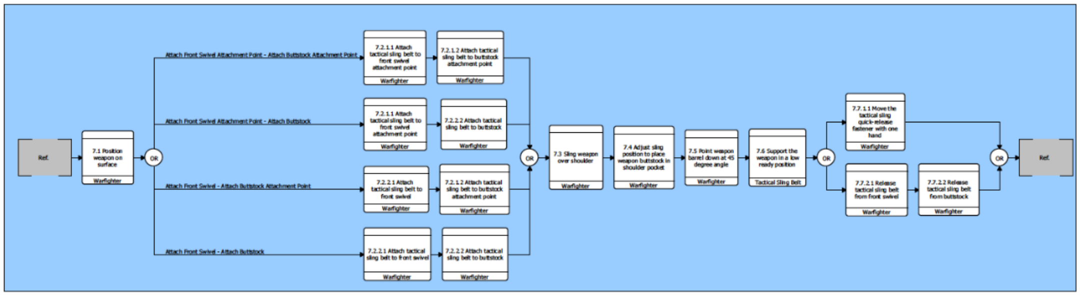
5G. Use-Case: Perform Operation in MOPP IV attire, with gloves on (Low Ready Position)



8

1.0 SCOPE

1.1 Scope. This specification prescribes the performance requirements for the Tactical Sling. The Tactical Sling allows the Warfighter's weapon to remain in a ready position while conducting non-weapon firing-related tasks.

1.2 Requirement levels. This specification lists two values for certain performance parameters. The threshold (T) is the minimum acceptable level. The objective (O) is the desired level at which performance of the Tactical Sling results in an operationally significant increase in capabilities. When only one requirement is stated, it is the threshold requirement.

2.0 APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 of this specification. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3 of this specification, whether or not they are listed.

2.2 Government Document. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitations or contract.

ARMY FIELD MANUAL

FM 3-22 Rifle marksmanship M16A1, M16A2/3, M16A4, and M4 Carbine

3.0 REQUIREMENT

3.1 Operating Requirements.

3.1.1 High Ready Position upon Release. The Tactical Sling shall keep the weapon in the high ready position (as defined in FM 3-22, Chapter 7) when the weapon is released.

3.1.2 Low Ready Position upon Release. The Tactical Sling shall keep the weapon in the low ready position (as defined in FM 3-22, Chapter 7) when the weapon is released.

3.1.3 Adjustment Ability. The Tactical Sling shall enable the Warfighter to adjust the sling length and secure it with the belt buckle, and assume all fighting positions stated below (as defined in FM 3-22, chapters 4 and 7).

- Individual Foxhole Supported Firing Position
- Basic Prone Unsupported Firing Position
- Alternative Prone Unsupported Firing Position
- Kneeling Supported Firing Position
- Kneeling Unsupported Firing Position
- Standing Firing Position
- Modified Supported Firing Position

3.1.4 Transitioning between Fighting Positions. The Tactical Sling shall not interfere with the Warfighter's transition actions from one fighting position to another.

3.2 Interface and Interoperability Requirements.

3.2.1 Webbing. The width of the Tactical Sling positioned on the shoulder of the Warfighter shall be no less than one inch and no more than two inches.

3.2.2 Ambidextrous. The Tactical Sling shall support both a left handed or right-handed Warfighter to operate the M16 and M4 series rifle.

3.2.3 Quick Release Capability. The Tactical Sling shall have a one-handed quick release fastener to separate the weapon from the Warfighter. The fastener when released must detach the weapon from the Warfighter without any further action. Loosening the tactical sling to remove the weapon is not considered as "fully separating" the weapon from the Warfighter.

3.2.4 Non-interference. The Tactical Sling shall not interfere with the use or function of the weapon to include but not limited to blocking the ejection port, interfering with the cartridges feeding, weapon charging and collapsing or extending the buttstock.

3.2.5 Compatibility. The Tactical Sling shall be operable while dressed in environmentally protective clothing (e.g. Mission Oriented Protective Posture (MOPP) IV, with gloves on).

3.2.6 Tactical sling attachment. The Tactical Sling Belt shall attach to the M16 and M4 series rifle without the use of tools (T). The Tactical Sling Belt shall be capable of attaching to the abovementioned weapons when configured with the M203 Grenade Launcher (GL) without the use of any tools (O).

3.3 Support and ownership requirements.

3.3.1 Attachment. The Tactical Sling Belt shall attach to the front swivel and buttstock attachment points (T). The Tactical Sling Belt shall provide the option to be attached to multiple points on the weapon (O).

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