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To CQB or Not to CQB: Designing a Tactical Training Range Tool Utilizing a Human Factors Approach

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Abstract: Close Quarters Battle (CQB) tactics are a fundamental strategy utilized in modern warfare. This study performs a task analysis of CQB training procedures. Through interviews and literature review, the multifaceted activities performed by training instructors (cadre) during training sessions were delineated. Utilizing both quantitative assessments and qualitative insights gleaned from interviews, operational context, and design requirements for a training device (range tool) were established. Subsequently, a Failure Mode and Effects Analysis (FMEA) was conducted to evaluate the effectiveness of this proposed range tool compared to the current method cadre utilize. Surprisingly, the findings revealed that the traditional method outperformed the range tool in reducing cognitive burden for cadre. This revelation underscores the significance of human-centered design principles, highlighting that prioritizing user needs does not always necessitate the integration of additional technology. Instead, it emphasizes the importance of aligning technological innovations with the unique demands and intricacies of real-world operational environments.

Keywords: Close Quarters Battle (CQB), Training Evaluation, Range Tool, Human Factors

1. Introduction

1.1. Background

In an era marked by asymmetrical warfare and urban combat, Close Quarters Battle (CQB) tactics have become increasingly important in modern military operations, particularly for elite units such as the US Military's Special Forces (King, 2016). CQB tactics focus on engaging adversaries in confined spaces at close range, such as buildings or urban environments, requiring specialized techniques and training to neutralize threats quickly and efficiently, while minimizing collateral damage and protecting innocent lives. Given the specificity and coordination demands of these tactics, training for this specialized form is crucial as any lapse in execution during real-time situations can result in grave danger and loss of life. The goal of these training programs is to create highly competent assaulters who prioritize precision, speed, and adaptability during CQB (American Special Ops, 2014).

Currently, high-level CQB training is taught to Special Forces Assaulters, such as Green Beret, at the Special Forces Advanced Reconnaissance Target Analysis and Exploitation Techniques Course (SFARTAETC) located at the John F. Kennedy Special Warfare Center and School at Fort Liberty, NC (formerly Fort Bragg). SFARTAETC teaches combat weapons marksmanship, CQB, and explosive and mechanical breaching through simulated conditions using pre-configured shoothouses and ranges (American Special Ops, 2014). During live training sessions, instructors (also known as cadre) record assaulter performance by marking an assaulter's mistakes (also known as infractions) and other notes. Based on publicly available information, cadre use pen and paper to record infractions and performance notes while simultaneously observing and assessing the CQB exercise from a catwalk within the shoothouse. According to anecdotal evidence gathered from the author's experience in the defense technology sector, this task is described as tedious, laborious, and time-consuming. It involves multi-tasking while wearing gloves and the arduous process of manually inputting performance data into a database for future analysis or reference. Due to the significant level of cognitive load and multitasking, inaccurate data insertion and erroneous assumptions can occur leading to inaccurate results.

To address these challenges, various defense contractors have attempted to develop and are still developing devices (also known generally as a range tool) to automate this data collection process for cadre (Booz Allen Hamilton, 2018; Leidos, 2022, 2024). The range tool's aim is to streamline operations by utilizing electronic input devices such as tablets to ease the recording of data, reduce potential errors and bias, improve cadre satisfaction and data digitization compared to the traditional pen and paper method.

1.2. Project Scope

This project aims to analyze the cognitive load experienced by cadre during training in order to inform the design of an effective range tool. Additionally, it seeks to compare the range tool's functionality, based on design requirements, with the traditional pen and paper method to determine superiority.

1.3. Guiding Research Questions

- What tasks and behaviors do cadre perform when recording data during training?
- Which of these tasks and behaviors are the most cognitively taxing?
- Given these taxing tasks and behaviors, what can be automated? What is required to design an effective device?
- Given these design requirements, will the range tool actually alleviate cadre cognitive load during the data collection process compared to the traditional pen and paper method?

2. Methodology

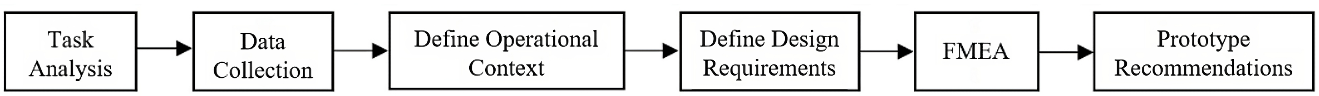

Figure 1: Visual depiction of the methods used in this capstone project.

2.1. Task Analysis

A comprehensive review of literature and materials was conducted, followed by multiple iterative reviews by one Subject Matter Expert (SME), resulting in the creation of a coherent task list. The task list was organized and formatted into an operational sequence diagram (OSD), facilitating clear visualization of decision points, process flow, and assigned roles (Kirwan & Ainsworth, 1992; Wickens et al., 2014). The task statements are relatively general in terms of detail, primarily due to the limited information authorized and available to the author. The OSD consists of over 80 tasks and 7 main decision points. Due to the diagram's substantial size, the OSD has been condensed into a symbolic format to illustrate the task flow for CQB training. Figure 2 shows the tasks both cadre (middle column) and assaulter trainees (right column) complete as time continues (left column).

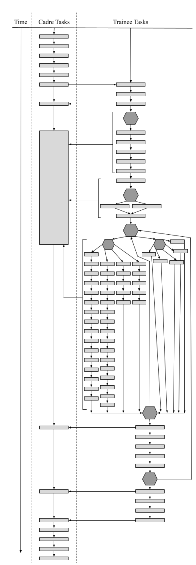

Figure 2: Simplified OSD for CQB Training.

2.2. Data Collection

Following the completion of the task analysis, the same SME was tasked with rating the cadre tasks based on various parameters including frequency, difficulty, importance, and consequence of error. This assessment was conducted using a seven-point Likert scale, as research suggests that seven points are optimal for human perception of rates (Finstad, 2014), a scale also utilized by NASA's Task Load Index assessment (Hart, 1990, 2006). The criticality of each task was determined by summing the parameter values (Stuster, 2019). Initially there were five SMEs, but only one SME was able to participate in all components of the study. It is acknowledged that obtaining ratings from multiple SMEs, preferably twenty or more, would yield a more comprehensive understanding and allow for the averaging of values in future studies.

Table 1: Task ratings based on task analysis.

#	Task Statement	Freq.	Diff.	Imp.	Conseq. of Error	Crit.
1	Perform lesson planning by establishing session's objectives and shoothouse configuration.	7	1	7	7	22
2	Prepare for training sessions and shoothouse entry by adhering to standard operating procedure (SOP) for attire, equipment, and materials.	7	1	5	7	20
3	Enter shoothouse.	7	1	7	7	22
4	Position on catwalk for optimal vantage point.	7	1	7	5	20
5	Retrieve grading and data collection materials.	7	4	7	6	24
6	Observe team behavior and soldier movement closely.	7	7	7	7	**28**
7	Record position of assaulters in stack order or at exterior entry point and/or other entry points by hand on paper to track aggression.	7	2	3	3	15
8	Record infractions and evaluation notes on the CQB technique performance of one or more assaulters in real time, by hand, on paper, while monitoring training exercises in multiple areas.	7	5	7	6	**25**
9	Record infractions based on if the post-clearing check is performed correctly.	7	7	7	7	**26**
10	Record infractions based on if the second check is performed correctly.	7	7	7	6	**25**
11	Wrap up recording infractions and performance evaluation notes.	7	5	7	3	22
12	Exit catwalk and shoothouse.	7	1	7	7	22
13	Debrief with trainees about the lesson and performance.	7	1	7	7	22
14	Insert performance data into a spreadsheet or database.	5	3	5	5	18
15	Analyze data or utilize software to understand class dynamics, identify leaders, and inform future lesson planning.	5	4	4	5	17

As depicted in Table 1, Task #6, which involves observing the CQB exercise, exhibits the highest criticality value with a value of 28. This suggests that it likely imposes the greatest cognitive load on cadre personnel. Task #8, #9, and #10 follow as the second highest criticality values suggesting these also impose significant cognitive load on cadre. Task #8, #9, and #10 have lower criticality values than Task #6 because of their lower difficulty ratings, whereas Task #6 consistently received the highest rating in each category.

It is intriguing to observe that Tasks #14 and #15, involving inserting data into the database and analyzing it, not only received lower ratings, but were also rated the lowest among all tasks with values of 18 and 17, respectively. This contrasts with anecdotal evidence from the defense technology sector suggesting that these tasks were perceived as arduous processes. The reasoning behind these low ratings likely stems from the routine nature of these tasks, whereas tasks involving observation and recording require more attention due to their varied nature.

2.3. Defining Operational Context

To ensure the development of effective design requirements, it is important to comprehensively understand and identify the operational contexts, constraints, user involvement, and abilities required to complete the tasks successfully.

1. Operational Environment: Demanding and multifaceted environment, requiring focused attention, expertise, and adaptability. Key features include:
   - Observation posts such as catwalks for cadre to assess assaulter performance.
   - Operating within dynamic training scenarios and live fire exercises which adds an additional layer of complexity and risk management to cadre responsibilities, requiring heightened situational awareness and safety protocol.
   - Operating within simulated adversaries and threat scenarios where cadre must monitor assaulter interactions and evaluate their decision-making, tactics, and engagement effectiveness.
   - Completing real-time assessment of assaulters such as identifying strengths and weaknesses, noting procedural errors or safety violations, and documenting constructive guidance to enhance performance.
   - Operating within varied lighting conditions such as low-light or no-light conditions.
   - Operating under time sensitivity as assaulters train for time-sensitive objectives requiring cadre to make rapid feedback decisions and rate performance under pressure.
   - Maintaining spatial and situational awareness as cadre multi-task observing and recording performance data.
2. Operational Constraints: Includes possible limited visibility, restricted movement, restricted hand dexterity and mobility due to gloves, time constraints, and inclement weather or extreme temperatures.
3. Operational Users: Consists of the cadre, but can also include assaulter trainees who may perform similar data collection tasks.
4. Operational Abilities: Drawing from the gathered data, it becomes evident that Task #6 imposes the highest cognitive demand as well as Task #8, #9, #10. These tasks involve observing the CQB training exercise and recording the corresponding performance data, aligning with the initial expectations of what tasks would be most taxing. Below delineates the cognitive abilities requisites for the proficient execution of these tasks, as outlined by Fleishman's taxonomy (Fleishman, 1975, 2022). These abilities serve as guiding factors for determining the design requirements and standards.

Table 2: Abilities required for taxing CQB tasks according to Fleishman's Taxonomy of Cognitive Abilities.

Selected Abilities	
• Control precision	• Reaction time
• Rate control	• Time sharing
• Arm-hand steadiness	• Near, far, night, and peripheral vision
• Manual dexterity	• Depth perception
• Finger dexterity	• Problem sensitivity
• Wrist-finger speed	• Information gathering
• Selective attention	• Spatial Orientation

2.4. Design Requirements

After completing the task analysis and defining the operational context, the next portion of the study involved establishing design requirements. These requirements are derived from the collected data, operational context, and the SME interviews. They emphasize the utilization of an electronic touchscreen tablet, as currently being done by defense contractors for this range tool. They are written based on guidelines set by the International Council of Systems Engineering (INCOSE) (Weck, 2015).

1. Functional Requirements: Over a dozen requirements were created referring to the specific technical and operational functions that the range tool must perform to meet its intended purpose such as implementing proper security measures, data transfer and storage capabilities, and operating in varied light and weather conditions.

2. User Requirements: Over a dozen requirements were created referring to the usability needs and preferences of the individuals who will interact with the range tool such as the type of touchscreen functionalities, type of interface visuals and navigation, and proper response to gloves and rough handling.

3. ISO Standards: Established by the International Organization for Standardization (ISO), these design standards should be referenced to ensure that the range tool and its interface are designed with consideration for human abilities, capabilities, and limitations (Stuster, 2019). The ISO 9421 series should be referenced which provides standards on human-centered design principles and guidelines for interactive systems (International Organization for Standardization, 2019). The 9421 series and specific standards within the 16750, 9022, 6061, and 7000 series were researched based upon the operational abilities listed in Table 2, prioritizing seamless interaction as well as ergonomic and environmental considerations for electronic input devices. Over a dozen standards were specifically selected to address each of the functional and user requirements defined for the range tool, ensuring its effectiveness and usability in practice.

2.5. Failure Mode and Effects Analysis

Failure Mode and Effects Analysis (FMEA) was conducted to identify potential failure modes that could increase cognitive load and frustration for cadre while using the range tool, based upon the established design requirements in section 2.4. Twenty failure modes were identified due to the range tool's software and graphical user interface, tablet screen surface, interface usage, software input and output, risk and cybersecurity, and hardware. The Risk Priority Numbers (RPN) for the failure modes varied significantly, ranging from 8 (the lowest RPN) to 560 (the highest RPN). The highest RPN value (560) is attributed to a critical safety concern - a cybersecurity breach - underscoring the importance of safeguarding against such risks. On the other end of the spectrum, the lowest RPN value (8) is valued so low because it is highly preventable. The subsequent RPN values, ranging between 450 to 200, are mainly preventable with proper training, albeit at the expense of additional time and financial resources. Moreover, more than 50% of the RPN values fall below 200 because they have lower Occurrence and Detectability ratings, indicating that they can be mitigated with proper software management. Lastly, while not all hardware failures have high RPN values, the relevance of these failure modes should not be ignored since any hardware damage or malfunction could render the range tool inoperable.

Based on the FMEA, a Critical Items List (CIL) can be formed to pinpoint specific functionalities of the range tool whose failure modes have high RPN values and pose risks to human safety and training success (Lindsey, 2010). Given the limited scope of range tool functionality, the CIL consists of three items: Cybersecure software, tablet screen and interface, and hardware. The traditional pen and paper method does not rely on any of these CIL functionalities and is unaffected by many of the potential failure modes outlined in the FMEA. As a result of this analysis, the traditional pen and paper method proves superior in terms of reliability and operational continuity during training scenarios.

3. Prototype Recommendations and Future Work

Based on the FMEA analysis, this study recommends staying with the traditional pen and paper method due to the numerous potential failures and the high risks associated with the range tool. However, if a range tool must be created, it is suggested to avoid using a gesture-based tablet and instead opt for a method that will offload the time-critical and cognitively demanding tasks.

An alternative to the current range tool design could involve the implementation of a transcriber system, allowing cadre to verbally dictate observations and infractions. This audio recording could then be automatically turned into quantitative data and stored. This automated process would alleviate the need for manual input, thereby reducing cognitive load. Such a device must be engineered to ensure clear audio reception amidst the loud and chaotic shoothouse environment. Alternatively, digital notepads such as the reMarkable and Kindle Scribe offer a familiar pen to paper experience while electronically storing data, thus streamlining the data input process. Such a device must be engineered to ensure usability with gloves and varied lighting conditions.

The next steps in this study would involve conducting additional interviews and data collection with more SMEs to gather more robust data and to extend the application of this tool to other forms of training, such as sniper training, also conducted at Fort Liberty. This will facilitate the development of a modular tool that can cater to diverse training needs efficiently.

4. Conclusion

Based on the comprehensive task analysis, data collection efforts, operational context considerations, and the design requirements outlined, the implementation of the current range tool designed and tested is not advisable. While it may initially appear to reduce cognitive load, there is high risk of increased frustration and failure. Therefore, it is recommended to either maintain the traditional pen and paper method or adopt another solution such as a transcribing device or a digital notepad solution where both provide benefits of digitized data storage while offloading time-critical and cognitively burdensome tasks. These alternative approaches ensure efficiency while minimizing potential drawbacks associated with new technological interventions.

However, it would be premature to dismiss the range tool entirely despite the highlighted drawbacks. Automation has proven immensely beneficial in various fields, including defense technology, where efficiency and accuracy are paramount (Parasuraman & Riley, 1997). This study does not oppose technology or automation per se, but rather advocates for a thoughtful approach to their implementation. Rather than indiscriminately adopting the latest technology, it is essential to thoroughly understand user needs and assess the suitability of each device. This study shows that a gesture-based tablet and application may not be the most suitable for this situation which can be used to guide future usability studies for the current range tool design. This study also reveals that cadre may be reluctant to depart from familiar traditional methods which can inform future studies in differentiating between the frustrations inherent to a CQB training task and those arising from unfamiliarity or inadequate evaluation training.

Ultimately, while the current range tool falls short of expectations for streamlining and decreasing cognitive load for CQB training evaluation, it serves as a critical stepping stone towards refining technological solutions tailored to the unique demands of cadre and assaulter trainees. By prioritizing user feedback and iteratively enhancing functionality, this study paves the way for future advancements that will undoubtedly revolutionize training effectiveness and operational readiness in the realm of close quarters combat training.

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